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Biographical Sketch of Nathan W. Dougherty

President of ASEE

The new president of ASEE has had a long career in engineering education and added to it he has had many summer excursions into the practice of the engineering profession. No early weather vane pointed in the direction of engineering, though early work with a hoe and hayfork got him nearer engineering by eliminating another major profession.

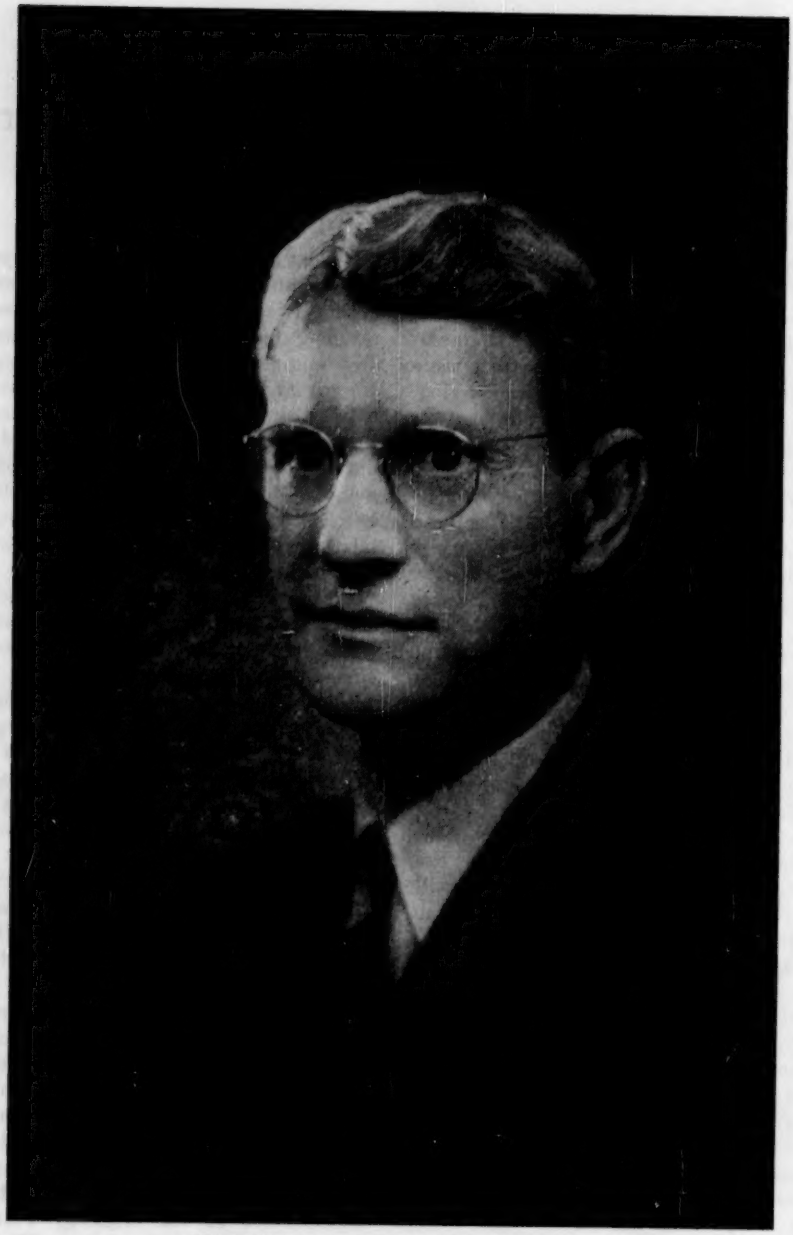
While still in the secondary school he was interested in highway and railway construction, and he had been especially intrigued by the construction of the Gay Street bridge over the Tennessee River at Knoxville. He remembers to this day the large derrick swinging steel into place on a cantilever reaching far out over the river. In later years he was pleased to meet the designer of the bridge and to read his book on artistic bridges which gave a picture of the Tennessee River bridge at Knoxville.

After graduation from secondary school he began his plans for entering the University. One day he drove to Knoxville for an interview and to get needed information about entrance requirements. It appeared that there was doubt about the standing of his school, and one of the professors asked if he had studied geometry. He replied that he had studied Wentworth's plane geometry. Then he was asked if he had worked any of the originals, and when he answered that he had worked all of them, his admission was assured. He entered the University of Tennessee in 1905 to study civil engineering and graduated in 1909.

After a half year spent in high school teaching and a half year in railroad construction he entered Cornell University as a student and instructor. For four years this combination continued, then after receiving two degrees, he cast his lot in the teaching field as assistant professor of civil engineering at George Washington University. To this time it was a toss-up between entering engineering practice or the field of teaching, but from 1914 the die was cast for teaching, and in spite of many opportunities to leave the field he has held steadfastly to the classroom, the laboratory and the chair of the engineering college administrator. After two years in Washington, he moved back to his alma mater where he has served for thirty-eight years, first as department head in civil engineering, and since 1940 as dean of the College of Engineering.

Brief excursions into engineering practice comprise such jobs as rodman and instrument man on railway construction during 1910, summer employment as junior engineer with the Southern Railway from 1917 to 1920, special assistant with the Bureau of Public Roads, now Public Roads Administration, for the summers of 1921 and 1922, special assistant with the Tennessee State Highway Department during the summers of 1923 to 1933. During 1934 and 1935 he was State Representative of the Coast and Geodetic Survey, operating the local controls survey for the state. During the period he employed nearly four hundred engineers, organized them into field parties and supervised their work throughout the state. During the summer of 1936 he was charged with the organization of the Highway Planning Survey of the Tennessee State Highway Department.

Though not an active research worker



NATHAN W. DOUGHERTY, PRESIDENT

himself, he has been interested in organizing and furthering research since his college days. As was the custom in 1909 his classmates selected him as commencement speaker for engineering. His topic was the "Need of an Engineering Experiment Station in Tennessee." When the station was organized in 1921 he wrote bulletin number 1, and the next year he wrote bulletin number 4.

These were the years of beginning activity in highway research on a national scale. He was one of those who organized the Highway Research Board, of the National Research Council. For a number of years he was a member of the committee on highway traffic, and contributed papers at the annual meetings. Before the SPEE combined the research, teaching and administrative divisions into the ASEE he, and others, had organized a research division of the Southeastern Section of which he was first chairman. He has served one term on the executive committee of the research division of ASEE.

In the land-grant college association he has also been active. He has served as chairman of the research committee for engineering; he has been secretary, vice chairman and chairman of the engineering division and is now completing his three-year term on the Executive Committee of the Land Grant Colleges and Universities Association.

His society activities have been extensive. In 1921 he was appointed to the first state board for architectural and engineering registration in his state and he has served continuously since that time. Since 1927 he has been chairman of the Tennessee Board. In 1934 he was President of the National Council of State Boards of Engineering Examiners, and during the years he has been active on many of the Council's committees, and has twice served as director for the southern zone.

He is now a life member of ASCE. He has served as a member of the education committee of that society and a member of the Board of direction from 1943 to 1946, and while on the Board he served as chairman of the committee on publications. He has contributed several articles and discussions to Civil Engineering and to the Transactions.

During the first decade of the life of ECPD he served as a member of Council for two terms, representing the NCSBEE, 1938 to 1944. While on the Council he served a term as member of the executive committee. From 1942 to 1948 he was a member of the committee on professional recognition and chairman from 1945 to 1947. From 1951 to 1953 he was a member of the Education Committee, charged with inspections in Region V, and since 1953 he has been chairman of the Committee on Student Development.

His most recent activity in a professional society has been with the National Society of Professional Engineers. He has served as chairman of the committee on education, as a member of the board of directors, 1950–1952, and as vice president 1952 to 1954. During the period he has contributed articles to American Engineer.

He has had a long contact with ASEE. He first became a member of the society in 1913, continued active for a number of years, then allowed the press of outside work to divert him from activity, then he became active again in the mid-thirties. He was a member of Council 1941–1944 and vice president 1944–1945. He has served on the Committee to Study Engineering Education After the War, the Committee on Improvement of Engineering Teaching and the present Committee on the Evaluation of Engineering Education. He has contributed many articles to the JOURNAL OF ENGINEERING EDUCATION. Locally he was acting chairman of the Southeastern section in 1941, chairman of three Fontana Conferences and published the proceedings of these conferences.

When he was a boy he heard that all work and no play makes Jack a dull boy. He has had his part in play. During his college career at Tennessee he played football, basketball and track and became captain of all three teams. On his re-

turn to the University of Tennessee his athletic career began all over again. He became chairman of the Athletic Board in 1917 and has continued this responsibility during all the years. He has been active in athletic affairs outside the University, having been the first secretary-treasurer of the Southern Conference, a member of its executive committee and its president in 1929. He was vice president of the NCAA twice and a member of the executive committee during the stormy years of the Sanity Code. At the present time he is secretary-treasurer of the Southeastern Conference. For an interim year he acted as commissioner for this conference.

In spite of his play and attention to many outside activities he is a member of Phi Kappa Phi, Tau Beta Pi and Sigma Xi from his college days and an honorary member of Pi Tau Sigma, Chi Epsilon and Iota Lambda Sigma.

He takes great pride in his family. In 1913 he married Agnes Monteith, a graduate, B.A. and M.A. Cornell University. Their five children, two boys and three girls, are all graduates of the University of Tennessee. The two boys Nathan and Edward graduated in civil engineering and and the three girls, Marie, Mildred and Agnes, two of whom graduated in liberal arts and one in business administration, married engineers. They now have thirteen grandchildren and hope that by the end of the present year they will have fourteen.

Sections and Branches

The **Michigan Section** held its annual meeting at the University of Michigan on May 8, 1954. Approximately 200 persons attended this meeting.

F. L. Schwartz presided at the General Session. W. P. Godfrey, representative to the Council from the Michigan Section, reported on the activities of the Committee on Society Functions and the Ethical Standards Committee. A. B. Bronwell reported briefly on the activities of the national group in relation to the Evaluation of Engineering Education, the Study of Graduate Programs, Humanistic-Social Project, Program for Summer Institutes, Programs of Summer Schools by Divisional Groups, Financing of graduate programs by industrial groups in conjunction with ASEE, Study of methods to get young engineering teachers more interested in activities of ASEE, General comments on the Annual Meeting in Urbana, Importance of Society activities at the Institutional level.

A panel discussion on "Evaluation of Engineering Education" followed. The panel members and their topics were: Dean G. G. Brown, "Curriculum," V. P. W. E. Stirton, "Selection and Guidance of Students," Dean Elect J. D. Ryder, "Development of an Engineering Faculty."

The following officers were elected for the year 1954–55: Chairman, C. C. Sigerfoos; Vice Chairman, G. H. Howell; Secy.-Treas., C. Fanning; Rep. on Council, R. H. Schoonover.

Educating Professionals

Editorial by N. W. DOUGHERTY, *President of ASEE*

Having been a participant in engineering education for nearly fifty years, and having observed the impact of engineering on industry for a longer period, I am thrilled at the prospect for the next generation. My generation has constructed the plants and equipped them for assembly line production; the new generation will refine them, develop new sources of power and make new products which are now hidden in the recesses of the imagination.

For the last two years we have been engaged in an evaluation of what we have done, and we have been projecting our plans for what we should do. We know that our kind of education is original enough to be counted indigenous to our soil; we know we have drawn from other sources, but we have made our education to parallel our industrial production. Sometimes we have feared that we have established educational assembly lines which take in a raw product and shape it for use in industry. Though we do some mass-production, we are not, by any stretch of the imagination, assembly lines. The colleges among us which are worth their keep still know their students one by one. The faculty, that is the good ones, still tailor their wares to the needs of their students.

So different are we from other lands that delegations are coming to us to discover our method of preparing and using engineers in industry. We have much to teach. Also, we have much to learn from all who know.

Evaluation

Two years ago President Hollister sounded the note of evaluation. Since then we have made study. For another year we will continue to study and to seek the direction we should go. By that time we should be able to take the next step in the "scientific-technological" stem (to use the notation of the 1940 and 1944 reports) of our engineering education. Other elements are receiving some general study, but the main motive of the Interim Report is the science and engineering science content.

This is as it should be. Our society has just finished and published a report of the improvement of teaching; it contemplates a study of graduate work and has already set up a plan for study of the other coordinate "humanistic-social" stem.

It will not be a year of evaluation but half a decade of study and evaluation. These are not the first efforts. Since the beginning of our society we have made constant study and appraisal of what we were doing. In every decade the Society has taken a new look at engineering programs with a view to inventory and projection into the future.

Sections and Divisions

Much work may be done by committees organized to make special studies, but these activities do not comprise the major activities of the society. In every subject matter field and in every geographical area there have been organized divisions and sections. These provide a forum for discussion and conferences and an opportunity to exchange ideas and experiences over very wide interests. We believe that the divisions and sections should be strengthened wherever possible. Where a division can make a study of an educational problem, the division should be charged with the activity. Special studies should be used to strengthen the whole society and especially the divisions and sections.

Locally the sections play an important part in our work. Fortunately, the education of engineers is not a local problem. Graduates in Tennessee may work in Maine or California, while graduates in Maine may work locally or in Minnesota or Texas. All the colleges are educating for work in any of the states or in any other nation. Local activities may, therefore, be keyed to the general themes studied by the society as a whole. An excellent example of this coordination has been exhibited during the last two years by programs of the local sections on evaluation of curricula, and the more than 120 reports from the engineering colleges themselves.

Let us strengthen the divisions and sections and thus bring the opportunities of the society to all the members both in subject matter fields and in local geographic areas.

Professionalism

An engineer is more than "one who directs the great sources of power in nature for the use and convenience of man"; he is a citizen of the community, the state and the nation. During the last fifty years much has been done to foster general recognition of the engineer as a professional practitioner. He not only builds a railroad, a bridge, a transmission line, a machine or a factory, but he evaluates their place in the life of today. His vision must not only comprise things and their use, but people and their living. He and the scientist have added quantitative thinking to the qualitative thinking of the philosophers and preachers.

The society must place more emphasis on professional concepts and professional activities. Our committee on ethics is doing a good work. We must realize that learning must be more than a veneer, that service must be real, and that the relation of confidence must be respected. These qualities distinguish a professional. They are taught by contact and contagion as well as by classroom assignment and laboratory exercise.

The committee on ethics is calling from the housetop that engineers must rededicate themselves to right living and noble practices:

> I was young and now I am old, and I have never seen the righteous in want or his children begging bread.

is as true today as when written by the Psalmist nearly three thousand years ago, and yet each generation must be reminded that "as a man thinketh in his heart, so is he."

In our teaching, in our section activities and in our committee work we should be constantly reminded that a profession consists of those who have special technical knowledge, who live by the service motive, who respect the relation of confidence and who follow a recognized code of ethics.

Educating the Whole Man

Our teaching objective is a citizen, a worker and a professional practitioner. Young men and women must be placed in an atmosphere where they will develop the spirit, the attitude and the approach of the engineer. It is not years of study or subject matter that measure the growth but intellectual maturity and professional development; these are important. In a community of scholars, where there is love of learning, the beginning engineer will find a climate which will warrant his spending time and studying subjects revered by his teachers. We should advise our students to spend the years, and to study the subjects, which will contribute most to their intellectual and professional maturity.

We travel on a journey with our faces to the eastward, toward the rising sun. As we travel we discover new lands, new ideas, new methods, and some of us must tarry to occupy and develop the new discoveries. Now and then we reach a knoll where we can look backward to the pathway we have traveled, and by the vision we are spurred to new efforts and new longings, always toward the rising sun.

As we urge our students on the way, it must be done with vision and enthusiasm, that they, as they travel, may perform their assigned tasks with requisite knowledge, judgment and skill.

Education for a Creative Professional Life

By L. E. GRINTER, *President ASEE, 1953–54*

(Presidential Address, Annual ASEE Meeting, Urbana, Illinois, June 15, 1954)

Introduction

This address will deal wholly with the subject of education—with engineering education as its central theme. However, as one grows in educational experience, he learns to view his own professional field as but one face of the many faceted jewel that every student's education should represent. It is futile to polish one face of a jewel while its many other faces remain no more attractive than common stone. Our product, the professional graduate, is still a jewel in the rough unless we contrive that he shall both reflect and refract light that may fall upon him from many directions. Since professional graduates will be bathed in the light from many sources they must learn to reflect or reject the non-essential, to refract or receive the useful and finally to absorb the significant.

If professional education is to attain the objective of educating the whole person it must start with the grades and continue until retirement. Of this lifetime of education, engineering teachers can by personal direction influence from four to seven years. Indirectly, their influence controls the success of the continuing educational process that extends far into the future. It is an appropriate objective for the American Society for Engineering Education to interest itself in all phases of the education of engineers from secondary study to graduate work and into the area of self-education after the termination of formal study.

An Active Year of Evaluation

The year 1953–54 was designated a Year of Evaluation and it has indeed proved to be so. The work of the Committee on Evaluation of Engineering Education has progressed steadily. During the year the Preliminary Report on Evaluation was mailed in October and the Interim Report was published in June. Some 120 institutions analyzed the Preliminary Report so that their comments and viewpoints could be taken into account in the preparation of the Interim Report. It is the desire of the Committee on Evaluation to have an equally wide consideration given to the Interim Report as a basis for preparation of a final report about a year hence. ASEE appreciates the aid of ECPD, of the Engineering Foundation and of the General Electric Company, each of which has contributed to the cost of the Evaluation Program.

Another evaluation study of great significance has been undertaken by ASEE with the financial sponsorship of the Carnegie Foundation. This is the Humanistic-Social Research Project under the direction of Dr. George A. Gullette with Dr. Edwin S. Burdell acting as chairman of the steering committee. This two-year investigation will attempt to evaluate the results brought about by the Hammond Report on "Engineering Education After the War" which emphasized the importance of the humanistic-social stem of engineering education.

In its investigation of engineering education the Committee on Evaluation raised the basic question whether the time had not been reached when modern physics should become a normal study for engineers. Through contact with the American Association of Physics Teachers a study has been encouraged of this im-

portant problem by departments of physics. Engineering deans have been asked to cooperate with any study that may occur on each campus under sponsorship of AAPT. As a contribution to our understanding of the basic problems involved in teaching certain concepts of modern physics to engineers ASEE has joined with the National Science Foundation in sponsoring two Summer Institute Symposia entitled Nuclear Physics in Engineering Education and Solid-State Physics in Engineering Education. It is believed that a comparable conference on Mathematics in Engineering Education can be arranged in due course.

The next related phase of the Evaluation study as visualized by the Committee is to determine the objectives, standards and desirable approaches to graduate study in engineering. The Division on Graduate Study has been encouraged to plan such an investigation and to prepare a proposal that can be presented to an appropriate foundation or to industry for financial sponsorship. It is worthy of mention that the grants to ASEE for the Evaluation Committee and for the other studies that have grown out of its work have already reached nearly twice the annual dues of ASEE members. In this way ASEE has been able to increase greatly its service to American education in the field of engineering. Further details of special activities of the Society will be found in the Secretary's Report.

Significant Influences Upon Engineering Education

Engineering education is the product of a large group of influences that are brought to bear upon engineering faculties. The two most obvious influences are the public school system from which engineering education draws its students and the employing group that accepts the resulting product. Actually, however, these are only two of a long list of influences, including such factors since 1940 as the needs of the several armed services. Of a different character is the academic tradition stemming from the liberal arts and science background of engineering education and the influence of the profession of engineering as exerted through licensing laws and the accreditation process. The influence of the public is in no sense inconsequential. Public opinion is exerted through appropriations to tax supported institutions and gifts to private colleges, through public health and safety legislation that requires specialized engineering services, and even more directly through the effect of public opinion, or regard, as it produces an incentive for young men and women to attain the distinction that the public places upon the profession of engineer.

The Public School Question

One of the major factors that necessarily influence the character of engineering education is the quality and quantity of secondary school preparation. In the viewpoint of those who measure these factors by the capacity of entering students to pass subject matter tests in mathematics and science, a continuing loss certainly is taking place. Whether there may be compensating factors that can contribute to engineering education if they are recognized and utilized is the corollary question. One must not forget that the revolution that changed our elementary and secondary schools from institutions that taught the three R's followed by such tough academic subject matter as English composition and mathematics into the progressive concept of preparation for life through social study and group activity has extended over thirty years. This ground could not be recovered quickly even if the present public discussions and debate should result in a counter-revolution. An entire generation will inevitably proceed from secondary schools to college under the strong influence of progressive education essentially as now constituted.

Of greatest concern to engineering teachers, I believe, is not the loss of subject matter content that the high school

graduate presents for college entrance, but the lack of development of the rigorous thought processes that accompany the study of mathematical analysis, English expression and the logical methods of science. High school advisors seem more and more inclined to discount the value of rigorous courses such as mathematics even though employers regularly point out that the ability to write clearly and to make simple mathematical calculations accurately are the most useful tools that the high school graduate can bring to industry or business. At one time educationalists resisted the requests of universities for such basic training on the theory that only a small percentage of high school graduates would enter college but that all high school graduates must be taught to live and to earn a living. This argument has now lost weight as more and more high school graduates enter college and as employers make it clear that the same academic subjects needed for college entrance provide the most direct contribution to industrial or business life and to the process of earning a living. These are English, history, mathematics, science and other academic rather than vocational subjects.

Teacher training is the process of teaching an art comparable to the practice as contrasted to the science of engineering or medicine. The social science behind the art of teaching is in its infancy compared to the great development of the physical sciences supporting engineering. Hence, the procedures of good teaching must be discussed largely in terms of personal experiences. This leads to the drawing of generalizations from the experiences of individuals which is not an unacceptable procedure but is a one-sided approach to truth. After a future teacher has been exposed to this method of investigation through many undergraduate and graduate courses, he may accept it as an essentially universal method of arriving at truth. Of course, in science there are other ways of establishing truth or lack of truth. We may develop an hypothesis and show by mathematical analysis that a contradiction is or is not involved. We often start with an established principle and by mathematical or physical analysis derive new principles for use. We may make controlled experiments in physical science and draw conclusions with definiteness and assurance that is never possible when dealing with human beings. A student whose education has been confined largely to the broad study of relations between human beings may be wholly untrained in the basic methods by which knowledge or truth is sought in other than the social fields. When such an individual becomes a teacher he can usually influence the methods of classroom teaching and even the subject matter independently of the course title under which his teaching is conducted. Naturally, such an individual is likely to place emphasis upon those areas where knowledge is sought by observation and exchange of experiences rather than upon an area where truth must be determined by the rigorous disciplines of exact physical measurement, mathematical analysis and scientific logic. Such must be the explanation behind a recently published examination in biology, concerned mainly with the subject of football, and similar impostures.

The above is a partial explanation of the lack of emphasis in the secondary schools upon mathematics and science courses but it fails to explain the neglect of written English. Probably the latter is explained by the extreme emphasis upon discussion in groups that is a credo of modern education. Great talkers often have not disciplined themselves sufficiently to learn the rules of correct written English. Hence, if the teacher is trained to do most of his personal thinking in discussion groups, he may feel constrained to use the same method with his students since his own ability to understand and criticize written English may not have been sufficiently developed to make it a part of his professional interest.

Of course, all methods of communica-

tion are of great importance in engineering. We should recognize a real accomplishment of modern education in the growing evidence that our students find little difficulty in participating in discussion groups or in orally presenting their ideas or in delivering a speech. We should look very carefully for evidence that the humanistic-social stem of engineering education may become greatly strengthened by pre-college studies conducted under progressive education. If it should be established that the humanistic-social interests of the student can be developed before admission to college, to the extent of becoming self-perpetuating, engineering education could be redesigned without great loss to supplement the other weaknesses of secondary education that are so evident to engineering educators. We should take a practical view of the secondary school situation which can only be changed over a long period of years and only after a change in philosophy has occurred within the training centers which are the colleges of education in our own institutions.

A Fallacy in Engineering Education

At this point I should like to discuss what has always seemed to me to be a grave fallacy in engineering education. This is the almost universal assumption that we can and, therefore, we must try to accomplish everything for every student. It is clear that this philosophy has two main sources; one is the influence of the faculty's specialized interests and the other is a deeply rooted desire to produce well-rounded engineering graduates. The result, however well intended, is not, I believe, in the broad interest of either the engineering profession or the graduates themselves. One can remember when electives were chosen freely by the engineering student. The pressure to accomplish everything for every student has restricted the free choice of electives until the end result is essentially a fixed curriculum for each student after an initial choice has been exercised.

The objection that is properly raised to the fixed curriculum is that engineering students are individuals rather than cogs. They have radically different interests and will serve radically different functions in society if given the opportunity to express and develop their divergent interests. Such interests range all the way from the spokesman or technical writer to the construction boss. We are dealing with such diverse personalities as future editors, promoters, designers, researchers, contractors, production men, patent lawyers, and entrepreneurs. It is a mental strain to conceive of such unlike individuals profiting equally from the study of any curriculum, but without electives it becomes patent that the college rather than the student must have been the main consideration.

An elective system to become significant must provide a truly free choice of electives. The assumption is made in the Interim Report on Evaluation that twelve per cent of the curriculum, equivalent to one semester of study, can be provided in free electives. Of course, such electives should be selected under guidance so that a scattered, uncoordinated result can not occur. However, the Committee would encourage concentration, by free choice of electives, in one or two of the following fields—humanistic-social studies, management, mathematics, basic science, engineering science, engineering analysis and preparation for design, thesis or practical technology. Any realistic combination of such elective studies leading to a planned objective would be an appropriate capstone for the undergraduate program.

Integration of Curricula Through Science

The history of engineering education could be written as a sequential development of new curricula. Even the ECPD list contains nearly twenty major curricula and a large number of accredited options. This splinter action was mentioned in the Wickenden report of 1930, and it was predicted that the trend toward new curricula would be reversed, but

this did not prove so. The centrifugal action encouraging a subdivision of curricula, development of new options, etc., is still present within the concept of specialization.

The subdivision of curricula has been supported up to the present by increased numbers of students. However, no predicted increase in students within the lifetime of the present generation of teachers is expected to exceed the enrollment of 1950. Other factors also seem to mitigate somewhat against new curricula. One such factor is the growing importance of science in engineering research and, in fact, in every phase of engineering activity. The common science background of engineering may be subdivided into the basic sciences of chemistry and physics, which depend upon mathematics, and the engineering sciences which have been listed by the Committee on Evaluation as statics, dynamics, strength of materials, fluid flow, heat flow, thermodynamics, electric currents, fields and electronics, physical metallurgy and the properties of engineering materials. It seems clear that basic science and engineering science as they grow more and more important in engineering may provide the cohesive or integrating influence that could draw all curricula closer and closer together. If some one hundred hours for scientifically oriented curricula of the four-year type might be looked upon as a common stem, as was suggested in the Interim Evaluation Report, then the opportunity really does exist to reverse the splinter process. The common requirements of basic and engineering science plus the humanistic-social studies may become the integrating factors.

By this it should not be assumed that the Committee on Evaluation recommends that one hundred hours of all four-year curricula should be identical. Instead of such standardization, the Committee recommends experimentation with all possible methods of orienting curricula more significantly toward basic and engineering science. Nevertheless, the evidence is strong that about a hundred hours are needed for the common background of science, engineering science, technology, and humanistic-social studies required by all engineers and that a semester of free electives is essential to permit effective individual development of the student, including some opportunity for educational preparation toward such selective functions as management, research or operation. Hence, it seems less probable that additional splinter curricula will develop in the future if variations are largely restricted to the remaining semester of study that exists within a four-year pattern. Perhaps there may even be some drawing together of similar curricula or options at the undergraduate level with specialization advanced into graduate study.

The Relation of Graduate and Undergraduate Study

The relationship of graduate and undergraduate study in engineering deserves formal consideration by ASEE. Also, standards of quality need to be established in the field of graduate work. For example, if it should appear that the accrediting process might have to be extended at any time in the future to the field of graduate study, ASEE should be prepared to say that the factors of significance in measuring the quality of graduate work have already been agreed upon. If this should not have been done, the opportunity would exist for another agency, which might not even be associated with the engineering profession, to impose standards upon engineering education.

We have available the Manual of Graduate Study in Engineering first published by a Council Committee of ASEE in 1945 and revised by a second such Committee in 1952. It contains careful thought that will be of great use in the process of evaluating the success of different approaches to graduate study in engineering. However, what we now visualize as needed is of a somewhat different character. It appears that a survey of the pres-

ent status of graduate study in engineering based upon statistical data and inspections of graduate programs followed by a comparison of the observed results with the procedures recommended by the Manual of Graduate Study would be of great value. After such a study it should be possible for the committee responsible for steering the investigation to draw conclusion regarding the objectives and standards of graduate study that could be discussed by all engineering colleges before acceptance and would then result in strengthening graduate work on a national basis.

Since a large part of graduate study in engineering is directed toward the production of research engineers, development men and creative designers, it is evident that it can be based effectively upon the professional-scientific type of undergraduate curriculum. Of course, graduate work in industrial management is of a different character and should be analyzed from a different viewpoint. Nevertheless, most graduate study for engineers should emphasize basic science and engineering science. It should usually be based upon a knowledge of mathematics beyond undergraduate requirements for engineers. The conduct of such work at an advanced level requires a teacher with science and research interests as well as a knowledge of practice. One may conclude, therefore, that the qualifications of the faculty, particularly in the direction of mathematical and scientific competence, including productivity in research or other creative work, represents the most significant institutional qualification for the conduct of graduate programs in engineering. It is in this direction that the attention of administrative officers in engineering colleges that offer graduate programs should be directed during the extensive recruiting of new faculty that will be necessary during the next decade.

The Feeling of the Future

Engineering is in the process of taking its place as one of the great learned professions. However, since engineering has grown out of the industrial arts there are vestiges of that tradition clearly evident in present curricula. As the development of science continues, the necessity that engineers be fully capable of applying scientific knowledge will inevitably reshape engineering curricula. Another influence in the same direction is the permanent shortage of engineering talent, particularly of the professional-scientific bent. However, engineering practice will remain an integral part of engineering study since art and science are mixed inextricably in every engineering design. The high usefulness of a knowledge of practice by the teacher is in illuminating the applications of engineering science to design as related to the creative function in engineering.

Since we are free to decide to look even beyond the next decade or so, it seems rather safe to predict that graduate work in engineering will become relatively very much more important in the total educational process. As basic science and engineering science continue to advance, a time will ultimately be reached when a four-year undergraduate education will no longer provide a sufficient basis for the development of ability to conduct professional engineering practice. A choice will then need to be made between extending undergraduate curricula or making professional status dependent upon the acquisition of an advanced degree. Considering the service that four-year undergraduate curricula perform in providing a broad education of use in many vocations it seems unlikely that such curricula will disappear. Hence, the acquisition of an advanced degree may ultimately become the first stage of recognition in the profession of engineering. We have been slothful in recognizing the future importance of the master's program and in developing high standards for its conduct as a basic contribution to the strength of the engineering profession.

The greatest weakness of engineering education has been neither the neglect of

practice nor of specialized science but insufficient attention to welding these together so that the student can explain the rules of engineering art or practice from his scientific knowledge. The student also lacks a sufficient depth of scientific study to enable him to understand the interrelationships between the half dozen or more specialized sciences with which he deals. In addition there has been a lack of understanding that engineering students can follow the road to high professional success only if they learn to accept full responsibility for their own education. Even though examinations that demand ability to originate a solution to a problem are difficult to plan, full of surprises, and often discouraging in the tangible or even measurable results returned, they represent the direction in which engineering education of professional stature must evolve.

Every course taught by a professor of engineering should to some degree carry forward the multiple objectives of professional education; that is, (1) to develop and work from basic principles, (2) to learn how to study after graduation, (3) to make use of the engineering or scientific method without permitting it to become restrictive, (4) to consider every engineering operation as it may influence the public welfare with due consideration of economic limitations, (5) to encourage a willingness to accept responsibility for decisions and (6) to express through individual work the highest ideals of the engineering profession. In large part these characteristics of engineering education apply to all professional education. However, one other characteristic seems paramount in engineering. The engineer must be inherently creative. To be successful he must be sufficiently inventive to bring his work to an optimum conclusion by using a synthesis of theories, concepts, techniques and experiences never before put together in the pattern needed. For this reason all engineering bears a close relationship to research. Of course, we are speaking of important, if not great, engineering, but anything less is inadequate as an objective for engineering education.

In summary, the profession of engineering requires the same elements of education as all other professions, but with greater emphasis upon creativeness. The highest professional education in engineering will weld art or practice with basic science in an approach so fundamental that it will level the walls of narrow professional specialization which have been raised primarily by the pride of craftsmanship. The key to professional education is stimulation of the desire to learn beyond the classroom and the college. This demands the acceptance of responsibility by the student, while in college, for much of his own education through willingness to attempt the solution of new problems. Through such experiences provided under the guidance of those who have themselves carried responsibility, the student will sense his coming accountability for operating in the framework of society for the general good and in the highest tradition of his professional group. The teacher who stimulates such a sense of professional responsibility in his students is a great teacher, deserving equally the applause of his profession and of his university.

ANNUAL MEETING—1955

Pennsylvania State University

State College, Pa.

June 20-24, 1955

Highlights of the 62nd Annual Meeting of A.S.E.E.

By JOHN I. MATTILL

Director of Publications and Assistant Director of News Service
Massachusetts Institute of Technology

One of the duties of the convention press room at each annual meeting of the American Society for Engineering Education is to prepare a summary of the meeting for reporters and editors who could not come. This turns out to be relatively simple. But to prepare a summary for members of the Society—many of whom were at more sessions of the meeting than the writer himself—is a vastly more hazardous undertaking.

Begin with statistics: temperatures at Urbana from June 14 through 18 ranged from highs in the 90's each day to lows in the 70's each night; by Friday A.S.E.E. members had witnessed a new Illinois record for prolonged 90-degree temperatures in June and all were ready to vouch for it.

The annual meeting itself was attended by 1513 men, 487 women, 138 teenagers and children, and (according to the record) 8 babies. The six summer schools were attended by 186 men who were not at the annual meeting. The Instrument Society of America–A.S.E.E. conference accounted for 72 of the 186, the M.E. for 66, Engineering Mechanics for 28, Engineering Economy for 10, E.E. for 8, and the Humanistic-Social Workshop for 2. Excluding babies, the overall attendance at the annual meeting and its affiliated conferences was 2324. Of these 528 were from the campuses of the University of Illinois and 1796 were from outside. Foreign delegates to the meeting totaled 28 men. Foreign wives and children totaled 5.

Clearly, whether or not the babies were included in the total, this was the largest annual meeting in the Society's history. A full schedule of diversions occupied the wives and children while the usual variety of conflicting events confounded their husbands.

Almost 160 members of the Illinois engineering faculty helped to plan and run the 62nd annual meeting, working under the direction of Dr. and Mrs. Lisle A. Rose. And there were 70 others from elsewhere on the Urbana campus, from the Navy Pier division in Chicago, and from among the townspeople, who also pitched in with arrangements. Ten Engineering Senior Student Service Committee Members also assisted.

Focus on Evaluation

The business of the 1954 annual meeting focussed heavily on evaluation. Members urged each other unanimously to devote more time to the basic sciences and to engineering science—at the expense of engineering art and practice.

Industrial representatives, agreeing with the teachers, said that they were unwilling to have colleges sacrifice the sciences and humanities to provide time for studying technology or administration. They insisted that their sales, manufacturing, and operating departments—as well as their research and development divisions—need engineers with strong scientific backgrounds.

The extent of this move to strengthen science was obvious in the interim report of the A.S.E.E.'s Committee on Evalua-

tion of Engineering Education first distributed during the meeting. Here was a proposal to have all engineering students—no matter what the field of their major—study in common almost five-sevenths of their total course. Only two-sevenths would be concentrated in the field of the major, and almost half of this would be as professional electives.

"The extension of our knowledge of basic science has opened doors to vast new areas of engineering endeavor and has expanded the foundations underlying many of the existing engineering fields. The response of engineering educators to these challenging developments of modern science will have a vital influence upon the course of engineering progress in this country," said the report.

This familiar theme was sounded again by S. B. Ingram, Director of Education and Training at the Bell Telephone Laboratories, Inc., at an electrical engineering conference on Thursday. "We are trying to provide our student with a kit of tools he will need in furthering successfully a career in creative technology. The technology in which he works gets every day more complex," said Dr. Ingram. "To work in it he will need tools appropriate to the more complicated job. He must be grounded to grow with his job."

The emphasis on science was continued by Dr. Lee A. DuBridge, president of the California Institute of Technology, whose address at the celebration of the fiftieth anniversaries of the engineering experiment stations at the University of Illinois and at Iowa State College turned out to be a major event of the meeting. "Maintain a close tie with the basic sci-

(Champaign-Urbana *News-Gazette* photograph)

Dean F. W. Trezise of Navy Pier presents a bronze plaque to retiring president L. E. Grinter at the annual banquet of the ASEE. Looking on is Major Lenox Lohr, President of the Museum of Science and Industry, speaker for the occasion.

(Champaign-Urbana *News-Gazette* photograph)

The new President of the American Society for Engineering Education, Dean Nathan W. Dougherty of the University of Tennessee (left), receives congratulations from two colleagues. At the right is Dr. Linton E. Grinter, Dean of Graduate Studies at the University of Florida, retiring president, and in the center is Dr. Leo J. Lassalle, Dean of Engineering at the Louisiana State University, elected vice-president for the coming year.

ences," was Dr. DuBridge's advice. "An engineer, after all, is putting to practical use today what scientists discovered yesterday." The work they must do tomorrow, he said, will grow out of what the scientists are working on today.

"The main purpose of science," said Dr. DuBridge, "is not to produce bombs and guns and radar—or even radios, refrigerators, and color television, but to advance human understanding."

(Thirty-nine professional and scientific societies named official delegates to this golden anniversary celebration. At least 900 members at the annual meeting visited a special exhibition of Iowa and Illinois experiment station achievements: network analyzer, uses of agricultural wastes, strength of culverts, highway material research, and vibration of curved beams from Iowa; reinforced concrete research, studies of railroad rails, betatron, boiler water treatment, and sound recording from Illinois.)

To further strengthen the sciences as a foundation for engineering education, Professor B. E. Meserve of the University of Illinois suggested at a mathematics conference on Thursday that engineers take these three steps: try to bring mathematics and education together; support high school programs and teachers in mathematics; and support programs to better prepare mathematics teachers.

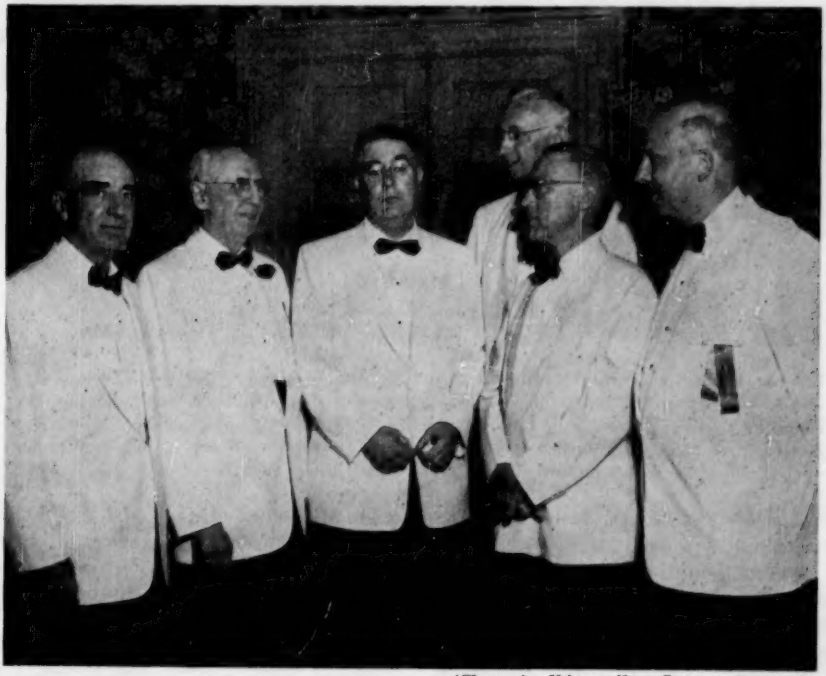
Dean Eric A. Walker of Pennsylvania State University, in his annual report as chairman of the Engineering College Research Council, said that "the colleges of engineering of the United States must get into atomic research if they are to support and conduct a vigorous and up-to-date educational program preparing for careers in the general field of atomic energy."

Still another aspect of evaluation came into focus when Dean Harold L. Hazen of M.I.T. said at a Wednesday afternoon E.C.A.C. conference, "The quality of its faculty is the basic, all-important determinant of quality at any school. This is also the most hazardous and difficult quality to appraise."

The evaluation project which sparked so much of this 1954 annual meeting received a special salute from President Lloyd Morey of the University of Illinois. "One of the most impressive of your activities," President Morey said in greeting the General Council, "is your promotion of high standards and the establishment of effective means of maintaining those standards."

Other Highlights

The local committee at the University of Illinois believed it could count 176 separate meetings, conferences, and sessions for which room and meal arrangements had to be completed. Not all these were concerned with subjects related to evaluation though the majority may have been. Other highlights were:



(Champaign-Urbana *News-Gazette* photograph)

Head Table Principals pose at the Annual Banquet: Left to right are Major Lenox Lohr, Museum of Science and Industry, Chicago, speaker for the occasion; President Lloyd Morey, University of Illinois, Dr. T. J. Higgings, Westinghouse Award winner; Dean L. E. Grinter, retiring President of ASEE, Dean Thorndike Saville, recipient of Lamme Medal; Dean W. L. Everitt, University of Illinois.

(Photo by Champaign-Urbana *Courier*)

Lee A. DuBridge (center), President of the California Institute of Technology, inspects the original betatron at the 50th anniversay exhibit commemorating the founding of the University of Illinois and Iowa State College engineering experiment stations. George Town (left), associate director of the Iowa Station, and F. Wheeler Loomis of the University of Illinois look on.

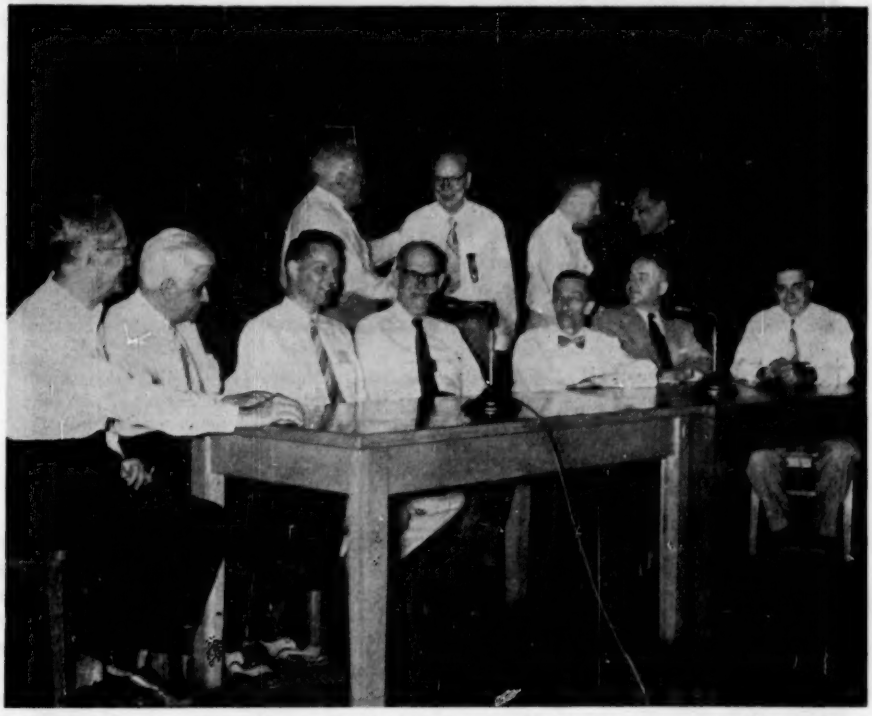
1. The demand from industry and government for new engineers continues to be greater than the current supply of graduates. Donald S. Bridgman of the American Telephone and Telegraph Company, reporting latest Manpower Committee figures, said that the decline in business activity and defense orders in 1954 has led to a 20 per cent decrease in the need for engineers. But, he continued, "with the relatively small classes graduating at this time, there is still substantial unfilled demand."

"It is apparent," Dr. Bridgman noted, "that the most important elements in this problem can hardly be reduced to numbers. Underlying all of them are the critical international situation and the demands which defense may create." In this connection, Dr. Bridgman pointed out that Russia is estimated to have graduated 43,000 engineers in 1953; the similar figures for the U. S. are 24,000 in 1953 and only 19,000 in 1954.

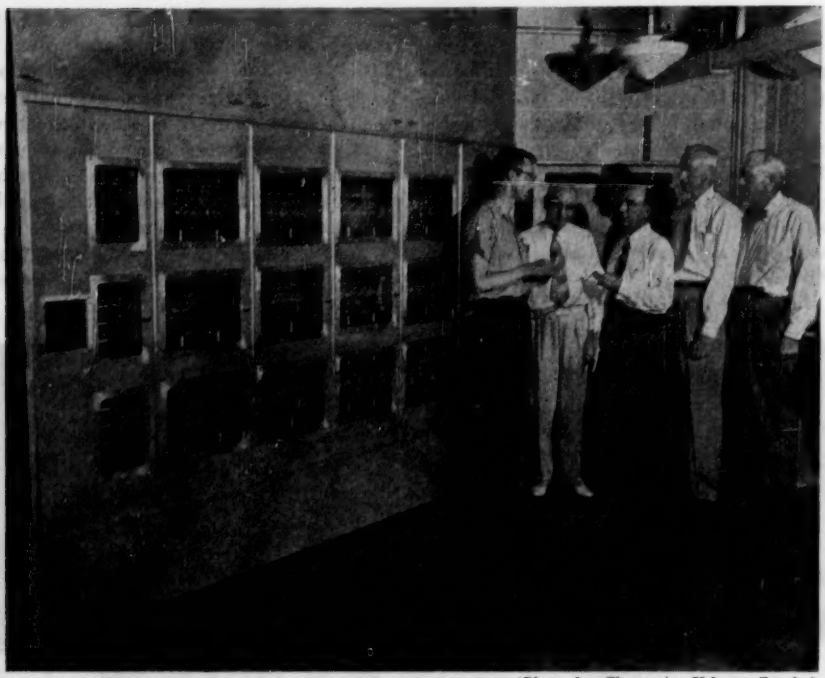
2. The Graduate Studies Division made a special study of the supply and demand for advanced engineering students. Dr. Henry H. Armsby of the U. S. Office of Education reported that graduate degrees in engineering increased six-fold in a 20-year period from 1929–30 to 1949–50 —and since then have declined slightly. In the case of doctor's degrees only, there has been a steady climb—even since 1949–50.

But, said Professor D. F. Peterson, Jr., of Colorado A. & M. College, the need is still greater than the supply. He listed two factors of "primary importance" in producing more graduate students: improvement in pre-college preparation for engineering and the sciences; and more inspiring scientific leadership, especially in the secondary schools but also at the undergraduate levels.

3. The elusive question of good teaching was before the E.C.A.C.'s General Session on Thursday morning, and the



A conference on international relations was sponsored June 17 by the ECAC at the 62nd Annual Meeting, ASEE, at the University of Illinois. Seated, starting from the left, are Leeds Gulick, Works Study Program, Foreign Operations Administration; Fred K. Bollman, Development and Management Section, Foreign Operations Administration; Joseph M. Roland, Chief, Specialists Division, International Education Exchange Service, State Department; Dean Arthur Hamilton, University of Illinois; H. T. Maser, Foreign Student Director, International General Electric Company; W. J. Holmes, Allis Chalmers Manufacturing Co.; and Joseph A. Cushman, U. S. Division of Immigration and Naturalization, Chicago. Standing are Reinhold Schairer, European Production Activity Agency; Dean F. M. Dawson, State University of Iowa; Dean Harold L. Hazen, M.I.T.; and R. P. Sinha, School of Mines of India.



(Photo by Champaign-Urbana *Courier*)

Notables at the meeting at the University of Illinois of the ASEE are shown inspecting the University's computer. Left to right are Prof. John P. Nash; President Lloyd Morey; Maj. Lenox Lohr, Chicago Museum of Science and Industry, speaker at the annual banquet; Dean L. E. Grinter, retiring president of ASEE; Dean M. L. Enger, emeritus, of the University of Illinois College of Engineering.

results came in threes: Dean R. L. Sweigert of Georgia Tech listed three factors for improving and maintaining good teaching: specific graduate school training for prospective teachers, continuing specific training for new teachers on their jobs, and careful recognition of good teaching wherever it appears. Professor E. C. Thoma of Purdue University listed three "munificent gifts" which make a good teacher: "professional esprit, the zest and the zeal to do a good job"; traits of personality, insight, sensitiveness, and perspective; and an ability to cast reflections of his earlier years forward to light the path of his students. And Richard W. Schmelzer of Rensselaer Polytechnic Institute said these three abilities mark a good teacher: to understand the purposes of his student, to use concrete illustrations on almost any problem, and to maintain the organization of his material from the beginning to the end of a course.

Mr. Schmelzer, as chairman of the Committee on Incentives for Good Teaching, proposed this formula for better teaching: "We need to create a climate of opinion so that the man who devotes himself primarily to teaching won't feel apologetic about it; won't feel that he is playing second fiddle to a researcher or a writer of textbooks; won't feel that he is not a valued member of the university community; won't feel, indeed, that it is somewhat futile to devote his efforts to

making himself as good a teacher as he possibly can."

4. A new plan to give foreign engineering students a chance to take summer jobs in American industry had its first public discussion at an E.C.A.C. International Relations Committee Conference Thursday afternoon. Dean F. M. Dawson of the State University of Iowa and Dean Hazen of M.I.T. proposed that foreign students earn part of the expenses of their schooling by working in selected American industries during vacation periods. While doing so, the students would learn at first hand what the American industrial system really means.

5. "The greatest single challenge facing the engineering profession today," said Cornelius Wandmacher, chairman of the Professional Training Committee of E.C.P.D., "is the professional development of young engineers in the first few years after graduation. It is a matter of greater concern as we demand higher and higher standards of performance in the engineering profession."

At another session on professional development, Professor A. S. Levens of the University of California (Berkeley) pondered the need to help engineering graduates attain higher professional stature by making available to them a variety of planned sequences for advancement in design, production, management, and other fields.

6. An urgent plea for more American young people to enter careers in engineering and technology came from Major

(Photo by Champaign-Urbana *Courier*)

Happy splashing during Champaign-Urbana's week of heat was made by youngsters of ASEE delegates during their special hours in Bevier Hall pool. Left to right are Maxine Jo Roth, 9, New York City; Melisa Merian, 8, Berkeley, Calif.; Sandra Huss, 7, Cogga Falls, Ohio; Bill Snyder, 9, Royal Oak, Mich.; Juan Sanchez, 8, Puerto Rico; and Bruce Williams, 8, Urbana.

University of Illinois engineering wives prepare favors for women's events held during 62nd annual convention of the American Society for Engineering Education.

Lenox Lohr, president of the Chicago Museum of Science and Industry, speaking at the annual banquet on Thursday.

"Careers in science and engineering must be sold to young people in increasing numbers if the future welfare of our country is to be served," he said. "Its success will depend on how well these professions can be dramatized. This task is the great new responsibility of educators in the engineering field."

Major Lohr pointed out that only 15 per cent of today's high school students in Chicago study algebra, only 4.9 per cent chemistry, 4 per cent physics, and 1.5 per cent solid geometry and trigonometry. "More young men and women," he insisted, "must be inspired to take technical courses. We must place our emphasis on the basic sciences in the lower grades, and teachers must develop the techniques of making science enjoyable and practical."

"Uninspired and inept instruction have too frequently made these all-important subjects a nightmare for the student," Major Lohr declared. "The teacher should emulate the good salesman: be convinced of his subject's importance, know that his student has a vital need which he can supply, and induce the student to really want it by employing all those devices which make it most palatable and persuasive."

Penn State Next

The gavel presented to retiring president Grinter at the annual banquet was made at the University of Illinois of wood originally part of the Fine Arts Building at the 1893 Chicago World's Fair. (A.S.E.E.'s predecessor organization was founded at the Engineering Congress of that World's Fair.) Vatican architects, instructing that the building housing Vatican art treasures sent to the

Fair be "fireproof," specified wooden columns three feet square. The gavel was made from one of these, and enough wood was left over to supply similar gavels to eight former presidents of A.S.E.E. who had somehow failed to receive gavels at the end of their terms. The Chicago Museum of Science and Industry is the present occupant of the Fine Arts Building, and the wood for those gavels was presented to Illinois by Major Lohr after it came to light during a recent remodelling.

The daily bulletin published at the 62nd annual meeting confidently announced on Wednesday morning that Professor A. M. Fountain of North Carolina State College, who hasn't missed an annual meeting during the past 20 years, held an attendance record. By Thursday morning the bulletin discovered that Dr. Armsby boasted 21 consecutive meetings, 1931 to date. The balloon burst completely at the annual banquet Thursday evening when Dean Grinter quietly commented that he was that evening attending his 25th A.S.E.E. banquet.

This argument will probably continue next year at the Pennsylvania State University, June 20 to 24, when each of these contenders will have added one year to his record. Dean Walker was heard to state that "it's always cool at Penn State," but nobody was sure whether this was sound salesmanship or rash boasting.

College Notes

A chair in mechanical engineering has been established at **Stevens Institute of Technology** in the name of George Meade Bond whose development of accurate standards of measurement has been credited with making modern mass production methods possible. The chair is endowed under a bequest of more than $300,000 in the will of Mrs. Ella Kittredge Gilson of Hartford, Connecticut, who died last November, according to an announcement by the Hoboken, N. J., engineering college.

Dr. H. P. Robertson of the **California Institute of Technology** has been appointed scientific advisor to Supreme Headquarters, Allied Powers, Europe (SHAPE), headed by Gen. Alfred M. Gruenther, Supreme Allied Commander in Europe. He is taking a year's leave of absence as professor of mathematical physics at Caltech.

Plans for a nuclear reactor to be privately financed and devoted solely to education and non-secret research in the peacetime applications of nuclear power were announced by Dr. James R. Killian, Jr., President of the **Massachusetts Institute of Technology.** The first nuclear reactor, planned for construction in New England, Dr. Killian said, will be used in an everwidening search for fundamental knowledge and for the solution of engineering problems in the new and promising field of nuclear engineering. Coupled with this new reactor are plans for a new building for the physical sciences.

George A. Hawkins, professor of thermodynamics, **Purdue University**, has been nominated to serve as a director-at-large of the American Society of Mechanical Engineers.

Education for Creative Leadership*

By MAJOR LENOX R. LOHR

President, Museum of Science and Industry, Chicago

The form and content of education best suited to give our children a full and successful life has, from time immemorial, been a subject of controversy, of constructive criticism and of constant efforts to improve its effectiveness. This is inherent, for there is so much to learn and so little time to learn it. Of the scores of subjects that might be pursued, there is time for only a relative few, and, due to changing fashions, the needs of the time, or to the predilections of the school administration, the curriculum may or may not include courses which would be those most valuable to the individual in later life.

Of transcending importance, however, is the method of presentation of any course, for, by its inspiration or ineptitude, there either is or is not inculcated in the student a desire for more education, an ability to think clearly and reason correctly, and an appreciation of the fact that the courses pursued are not merely academic abstractions but actually the tools with which to carve a future career. As education is made a pleasurable and satisfying experience, rather than a dreaded chore, its effectiveness will be increased proportionately.

The engineering colleges have a keen appreciation of their responsibilities and are fully aware of their still-unsatisfied needs. This is evidenced by the large attendance of our foremost technical educators at this meeting of the American Society for Engineering Education and by exhaustive reports of your committees. This group would be the last to contend that the goal had been reached.

The science of engineering began in the early 1800's on an academic foundation. It differed radically from the practice of the builders of olden times whose know-how was arrived at empirically. It differed from that of the early lawyers and doctors who "read" law or studied medicine in the office of a practitioner. Involving the basic sciences and theoretical considerations, the science of engineering could best be learned in the classroom from instructors especially qualified to impart knowledge in their own specialized fields. There has been a constant striving to meet the technological needs of the times, to incorporate in the curriculum each advance in scientific knowledge, and to produce better-rounded graduates. Our American engineering colleges are doing a superb job in training engineers to be engineers; that is, in cramming as much technical knowledge into those who want to be engineers as they are capable of absorbing.

That is not enough. Our continued prosperity, and even our very existence as a nation, may depend upon members of this Society going far beyond your green campuses and doing a job more fundamental than any prescribed in your college registers. Ways must be found to induce more youngsters to aspire to careers in technology, and they must be better prepared on entering college.

Critical Shortage of Engineers

We are all aware of our critical shortage of engineers. With less than 20,000 graduates this year, our needs are in excess of 40,000, with the prospect of a greater number required by industry in

* Address given at the Annual Banquet of ASEE, University of Illinois, June 17, 1954.

the years immediately ahead. Our military authorities are justly alarmed for the national security. Modern wars are conflicts of technology, demanding more and better engineers in the Services and in the production of arms. We are rapidly losing the edge which we have had on Russia. Our superior technical knowledge has heretofore offset their greater manpower and supply of natural resources, but the gap is closing. Reliable information indicates that half of the curriculum of the secondary school in Russia is devoted to scientific and technical subjects and that one-third of their college students are taking engineering.

Our national abundance has aroused jealousy and even enmity in other parts of the world. There are those, not being capable of achieving a comparable standard of living by their own efforts, who would like to undermine ours. With 6% of the world's population and less than 7% of the land area, we in the United States make, use, and produce nearly 50% of the world's goods. In three hundred years this nation has progressed from a virtual wilderness to the highest standard of living the world has ever known. How has this been achieved?

America was settled by freedom-loving men of strong faith with the courage to face the unknown and to carve their destiny despite hardship and adversity.

They came to an economic and industrial vacuum, without the restrictions imposed by centuries of precedence and tradition to confine their endeavors. It was a virgin country where they could plan, build, and develop according to their native common sense and initiative. They devised a system of government permitting competitive enterprise with the hope of reward for success and the risk of loss for failure, but with the liberty to try and try again. They built an industrial empire with a philosophy of mass production, that there might be an abundance of goods which most people could afford to buy. With ample risk capital, farsighted and efficient management, a high level of general education, and competent inventors, scientists, and engineers, we have come a long way with amazing rapidity.

Since the year 1900 our population has doubled. And, due to the use of power tools on the farm, the proportion of farmers (to other workers) necessary to feed the rest of the nation has materially decreased since the turn of the century. Due to these two factors, the number of workers available to perform or build all the rest of the services, necessities, and luxuries of life has increased from 17,000,000 to 55,000,000. But this represents only a part of the gain, for during these five decades, the tools and power which have become available in industry have increased the productivity of the worker as much as a hundred-fold.

Every step in this progress has required the services of the engineer. In 1900, there was one engineer to 290 industrial workers; in 1954, the ratio is one to 65. As we extrapolate the curve, we wonder how we can supply the demand for more and more engineers. What can the engineering colleges do to meet this potential crisis? They must go beyond their cloistered halls and work in other fields with the same effectiveness that has accomplished so much in improving their own curricula.

Need More Properly Prepared High School Graduates

A farmer cannot produce a good crop from poor seeds, nor can a skilled mechanic produce good tools from inferior steel. The technical colleges cannot produce sufficient well-trained engineers unless they have an ample supply of properly prepared high school graduates to draw upon. The acute problem really begins at the end of the second year in high school, for, if by this time the student has not made up his mind to pursue a technical career, he is unlikely to take those courses which are an essential foundation for the tough curriculum of the engineering college. Few

youngsters in their middle teens have made up their minds about what they want to do in life, unless it be to pursue some romantic interest popular in the events of the day. Most of them can name scores of ballplayers, movie stars, military heroes, and even some scientists and inventors, but few could name a single prominent engineer or tell who was responsible for a current outstanding engineering project. The problem is how to encourage those with natural mechanical or scientific inclinations but without a realization of their latent aptitudes to consider a technical education.

The engineer has not been glamorized as have those in other professions. He is seldom the hero in a novel, TV script, or motion picture, and rarely appears in the news of the day. There are a number of reasons for this situation. The ethics of the profession frown upon personal publicity, and many engineers consider it beneath their dignity to appear in the spotlight even for notable accomplishments. Engineers do not work directly with the public in the same way as the doctor, the minister, or the lawyer, but in general they are submerged in large corporations, government agencies, and educational institutions.

Many a capable youngster is groping and is uncertain of what he wants to do. What can be done to focus his thinking on engineering? Creative work, service to fellow men and country, the building of great structures, the thrill of discovery in research may offer arguments fine and true, but they are unlikely to motivate the youngster whose mind is partly on the next school dance or on whether he can borrow his father's car.

How can engineering be so dramatized over the length and breadth of the land that thousands of boys and girls who have not yet determined upon an engineering or scientific career will be persuaded to look ahead with enthusiasm to the grueling grind? Argument, no matter how persuasive, must be supplemented by an appeal to the emotions. Appeals to reason may work with an individual or a small group, but with little success with unseen masses, as amply proven by the experience of radio broadcasters. Since audience mail has proven the best way of determining program popularity, all returns are systematically recorded. The ratio of response from appeals to the emotions, as compared to serious broadcasts, indicates a ratio greater than 100 to 1.

A ten-year-old infantile paralysis victim sang "Over the Rainbow" and asked for contributions to the March of Dimes, and 1,393,590 responses came in. Listeners were invited to send a cheery card to a youngster who had been bedridden with rheumatic fever since babyhood. He received over 100,000 pieces of mail and 450 gifts, including train sets and bicycles.

On the other side of the picture, one broadcast on the functions of the United Nations drew 1030 letters, and a similar one at a later date, only 45. A speech by Herbert Hoover on a public issue of national consequence brought in 2998 responses.

Emotional Appeal

A classic example of the emotional appeal was an episode on a radio program entitled "Ma Perkins," a fifteen-minute "soap-opera" serial, running five times a week. Ma Perkins was a homey character with a simple, appealing family, whose experiences were as real to her loyal audience as those of their next-door neighbors. They rejoiced with her successes; they grieved over her tribulations. At the appropriate season, Ma Perkins decided to plant some petunia seeds. She prepared the ground in her little garden, and the seeds were sown. Day by day the audience followed their progress. The ground was watered, the tiny sprouts broke through the ground, the weeds were pulled, the plants matured, and lo, one day a bloom appeared. At this stage the announcer came on the air and said, "How would you like to have some of Ma Perkins' own petunia seeds?"

Let us analyze the results of this simple episode critically. It did not occur to the audience that Ma Perkins, her garden and seeds were a figment of the imagination. They did not visualize an actress reading a prepared script before a microphone, freshly typed by a professional script-writer. They did not stop to consider that, even in character, Ma Perkins would not have had wholesale quantities of petunia seeds. Yet they were motivated to go through the involved process of securing a dime, a box top, and the complications of mailing. When the responses were counted, over 1,100,000 dimes had been sent in, taxing the resources of the seed wholesalers of the country. That appeal went direct from the ear to the heart, and by-passed all mental processes; for had the facts been considered logically, the dimes would have been few. A careful tabulation of the returns showed that they represented a fair cross section of the American people. Appeals to the emotions react on all.

Careers in engineering must be sold to young people in increasing numbers if the future welfare of our country is to be served. Its success will depend on how well the profession can be dramatized. This task is the great new responsibility of educators in the engineering field.

If they appreciated the needs, teachers as far down as the middle grades could also be of material help in fostering an urge for technical careers, especially in those mentally, and temperamentally suited. Many a lad has been lost to engineering through lack of the right appeal in preadolescence.

A Science Fair held last month at the Museum of Science and Industry, the result of a competition among high school students, resulted in over five hundred exhibits, chosen from thousands. Each was demonstrated by the students who designed and built it. These exhibits evidenced an extraordinary knowledge of scientific principles. They ranged from models of reactors and jet engines to collections of butterflies and fossils. The Fair attracted over 26,000 other students on the first of the three days that it was open, many of whom undoubtedly received a real inspiration from it.

There was recently installed in the Museum of Science and Industry, Colleen Moore's Doll House, a fabulous fairy castle costing over a half-million dollars. You might well ask, "What has this to do with either science or industry?" Indirectly, it has a lot, for 100,000 youngsters a year will come to see it who would not walk across the street to see the finest exhibit on science or industry. During their visit they will be exposed to intriguing technical exhibits, and many will have their interest aroused. It is better to proselyte among those not already convinced.

Stimulation of Interest

The stimulation of interest in technology is the primary challenge, but this is only the first half of the problem, for even when successful, it demands a quality of instruction in the third and fourth years of high school, particularly in the basic sciences, that must be adequate to prepare the graduate for his years in college. A recent survey among a large number of high school seniors indicated that the percentage who had taken courses in the basic sciences was alarmingly low: 15.4% in elementary algebra; 1.5% in solid geometry and trigonometry; 4.9% in chemistry; and only 4.0% in physics. Chicago public high schools do not require mathematics as a prerequisite for graduation, and some do not have a single class in physics.

The trouble goes back to the elementary schools, because if the pupil has not mastered such simple fundamentals as the multiplication table and decimals, he is so handicapped that each succeeding course in science becomes too difficult to warrant going further. It is human nature to cherish the memory of a pleasant experience and to draw down the curtain of oblivion on one which was repulsive, boring, or too difficult. Many a student,

on passing his final examinations in mathematics, physics, and chemistry, has exclaimed, "Thank goodness, that's over! Believe me, I would never want to go through that again." Uninspired and inept instruction has too frequently made these all-important subjects a nightmare for the student. His attitude is communicated to his fellows, and they shy away from subjecting themselves to the same ordeal.

With different teaching techniques and a more appealing presentation, the most difficult subjects can be made interesting and enjoyable, and fewer students would fail in their first year at college.

The teacher could well adopt the art of the salesman, a term which would not have an obnoxious connotation if the attitude of the true salesman were better understood. He is neither a peddler nor a hawker. A real salesman is one with high ethical standards, because his stock in trade for repeated sales is the confidence that he builds up in his prospects over the years.

He must know his product thoroughly with all its qualities and limitations. He must conscientiously believe in the merit of his product, for he will make sales, not so much by his words as by the conviction emanating from him. He will thoroughly analyze the needs of the prospect and be the first to recommend a competitor's product if his own brand will not satisfy the need. He believes that his product can profitably supply a need which his prospect may not realize exists. Clearly and logically he presents his case. He refrains from exaggeration, believing with Benjamin Franklin that a mild statement is the most convincing.

Three shoe-shine parlors were established in a single block. The boy at the first corner erected a sign saying, "The best shoe shine in the United States." The one at the other corner, not to be outdone, had his sign read, "The best shoe shine in the whole world." Little area remained for the one in the middle of the block, so his modest sign read, "The best shoe shine in this block."

There are no salesmen behind the Iron Curtain, the public being permitted to buy certain things and ordered to buy others. Too much of this attitude exists in the classroom. The teacher should emulate the good salesman—know his subject thoroughly, be convinced of its importance, know that his student has a vital need which he can supply, and induce the student really to want it, by employing those devices which make it most palatable and persuasive.

Selling is Essential

Selling, in the sense in which I am using it, is essential in all the media of mass education. We have mass education, in some degree, in magazines, newspapers, motion pictures, radio, television, expositions, churches and museums. While the effective techniques of teaching in all these media are essentially the same, they differ radically from those of the classroom. The characteristics of formal education diverge widely from those of mass education. However, they complement each other, rather than overlap or compete.

In formal education, especially below the college level, the students are essentially of the same age and scholastic and cultural backgrounds. Attendance is compulsory and under discipline. The courses are coordinated and sequential, with individual attention from the teacher. There is home preparation, repetition, and competition with fellow pupils.

Those exposed to mass education are of all ages from two to toothless. They are of all educational backgrounds from kindergarten to Ph.D. There is no homework, no competition for marks or parental approval. If there is repetition, it is for things they know and enjoy, rather than for subjects difficult to learn. Yet this heterogeneous group is, in general, exposed to the same things simultaneously.

Since attendance in mass education is voluntary, special ingenuity is required to intrigue interest and make it an enjoyable experience. Use of all the devices of showmanship, drama, and entertain-

ment is necessary to hold the interest of the student. The explanation or demonstration must be so lucid and understandable that the visitor or reader feels a compelling urge to see it through.

In the classroom the student is held physically by discipline, but his mind and attention may have drifted far afield. Restraint is a poor substitute for holding attention, interest, and enthusiasm. He who attends class with pleasurable expectation is more susceptible to learning than he who considers it an inescapable obligation. That which is learned through understanding rather than rote memory will remain as a guidepost when theorems and formulas are long since forgotten. That some gifted teachers are able to accomplish this only emphasizes the lack in others.

I well remember my professor of mathematics at Cornell who conducted an eight o'clock class, six days a week. He had the knack of making real, and applicable to the experiences of life, abstract and academic paragraphs in the textbook. I recall that in a problem involving the intersection of two curves, he described a cottontail rabbit sitting in a hedgerow. A dog enters the field, sees the rabbit and takes off after him. The rabbit runs in a straight line, but the dog, instead of heading him off, runs directly at him and hence on a curve. It took two pages of calculus to catch that rabbit, and, though it was forty years ago, I can still see that hound dog chasing it across the field.

Abstractions, the practical application of which seems to end with memorizing them, would take on a different aspect if tied in to those normal experiences of the student which affect him personally, or if the problem can present a predicament or experience in which, in his imagination, he can make himself a part.

Successful mass education must be so planned that a stimulating interest is aroused on first contact, for normally split-second decisions are made. As we thumb through the pages of a favorite magazine, we pass up several articles until some outstanding picture, title, author or catch-phrase causes us to pause for a second look. As we spin the dial of our radio, something causes us to stop at one station after passing up several others; as we walk through a museum, exhibits on all sides demand our attention, but we see only a few. Something must intrigue our fancy at the first brief glance to invite a try.

Interest Must Be Held

In mass education, interest must be held from *instant* to *instant*, for if it is relaxed, even momentarily, the student cuts class. As we start reading a column in the newspaper or an article in a magazine, the first paragraphs hold our attention, but let the author become inept, inane, or just boring, and we turn the page and seek something new. We may be listening to a radio program with interest, but let the speaker get dull or the interest pall, and that powerful censor, the thumb and forefinger, comes into play and we spin the dial and are lost forever.

In museum exhibits, the greatest educational advantage is achieved by first showing the people what they want to see, for then they are willing to look at what you think they ought to see.

The Museum of Science and Industry in Chicago is an institution for mass education. It is not a museum in the classical sense. It is not a repository of historical objects or of scientific collections in endless rows of glass cases. It endeavors to demonstrate the laws of basic science and their application to industry. Through sequential exhibits which tell a story, it portrays the elements which have made America pre-eminent in production. This year it will be visited by two and a half million people who will spend an average of three hours within its halls. Many of these are organized school groups. Last month in a single day there were 92 schools represented from seven states. It is a healthy sign that teachers are realizing that, while basic education and the ability to think a problem through can be taught

only in the classroom, exhibits demonstrating the laws of science and the methods of industry are essential in rounding out the student's conception of the world in which he lives.

But the real key to the situation is whether the youngster enjoys the experience and wants to come. In a recent article in the *Saturday Evening Post*, the author epitomized the Museum's exhibits by saying, "You wouldn't think that many people would go out of their way to detect the radioactivity of an isotope of strontium, but in Chicago, children cry for it." He referred to a tank of live frogs, some of which had been made radio-active. Visitors could locate the "hot" ones with a Geiger counter.

We have found at the Museum that even the most complicated of scientific concepts, such as those in the nuclear exhibit, can be made clear with the proper demonstration equipment, by a step-by-step sequence of presentation, and by eliminating those unessential details dear to the heart of the specialist. It is particularly necessary to start the explanation on page one. The expert is too likely to assume that the first steps are obvious and familiar to everyone, when actually they may be unknown to those whose interests lie in other fields.

All too frequently textbooks and museum labels are technical gobbledegook written by experts more to impress their associates in the field than to enlighten the student or public.

The textbook definition of the Second Law of Thermodynamics is, "No change in a system of bodies that takes place of itself can increase the available energy of a system." Lord Kelvin's elucidation of the law should make this perfectly clear to the ladies present. He explains, "It is impossible by means of inanimate material agency to derive mechanical effect from any portion of matter by cooling it below the temperature of surrounding objects." Kettering, with the knack of making complicated things simple, says all this means is, "You can't push on something going faster than you are." Perhaps not scientifically inclusive, it at least gives the student an idea to start on, and he can progress to more exactitude from there. "The mind of man is less confused by a mystery he cannot understand than by an explanation he cannot comprehend."

Some time ago we were entertaining a group in the educational field at the Museum. They observed a "mobile," a series of arms swinging in different planes, which was then new. It was purely architectural and decorative and had no other significance. Several inquired what it was. At lunch, with the purpose of being humorous, I described it as a turbo encabibulator, of which "the suspensorial multiple planar ovoids, on their circular swings, exhibit the skor displacements by their stepform-phased reciprocatory excursions. In their amplitudinal range these exponentially damped oscillations deplenerate co-sinusoidally." This was sheer nonsense and gibberish, but instead of the laugh I expected, they nodded their heads in understanding approval.

Important Function

An important function of the Museum is to make real that which the student learns theoretically in the classroom. He may be able to give a parrot-like recitation of a theorem without understanding its application. Incidentally, high marks are sometimes a poor criterion of what the student really knows, for his endeavor to get them may be at the sacrifice of basic comprehension.

Newton's Law of Motion (there used to be three when I went to school) contains eighteen words with two footnotes that explain terms. An average student should be able to memorize it in a few minutes, and be marked perfect on a subsequent examination, yet might have only the vaguest idea of what it means. To illustrate this principle, I described an exhibit to a group of secondary school physics teachers planning tours for their

classes. I asked the group if they knew Newton's Law of Motion. Somewhat taken aback, they allowed that they did. So I continued:

There is a turntable about six feet in diameter, free to turn on its pivot. Around the periphery is a miniature railroad track. When a button is pushed, electric current starts a small train. Then, I asked, what happens? They said that for every action there is an equal and opposite reaction, and when the train moves forward, the track revolves backwards. Correct. Now I continue to hold the button—what happens? Some thought the relative motions would continue, but, of course, when the train reaches full speed, there is no longer the force of acceleration, the track stops and the train continues merrily on. Now, I take my finger off the button, hence cutting off the current. What happens? Silence! As the train slows down, the force of deceleration is in an opposite direction to the travel of the train, hence its reaction being forward, the track starts up in the same direction as the train is moving. They all wanted to go up and push the button for themselves.

They also saw a miniature cannon mounted on a track. While still stationary, a cannon ball was spring-fired vertically into the air and, as was expected, it dropped back into the muzzle of the cannon. Then the cannon was moved rapidly along the track and, while still in motion, the ball was again fired. It performed a graceful curve in the air and again dropped back in the still-moving muzzle of the cannon.

Demonstrations of this kind make an indelible impression and an understanding not possible with words alone.

In the exhibit of the Commonwealth Edison Company, there is a demonstration of the economy of electric power. The public is invited to pedal a stationary bicycle to which is geared an electric generator. Appropriate meters and a glowing lamp indicate the amount of physical work required to produce a given amount of electricity. An unusually strong teen-ager, by exerting maximum effort, can register one-half kilowatt. If he is able to maintain this rate for two seconds he is awarded a metal disc in which is imbedded a one-cent piece. Around the edge is this inscription: "If you continued this rate of work for one hour you would produce one cent's worth of electricity." The recipient can readily visualize that this would be a hard way to earn a living. It would take four husky men to produce a half-kilowatt for an hour, and if they were paid the nominal sum of a dollar an hour, it would make the cost ratio of manpower to electrical power 400 to 1.

No label could carry so effective a message as this personal experience. Exhibits which have visitor participation are the most popular and effective. The visitor does not want to be told. He wants to find out for himself through the use of his own muscle and brain. This is demonstrated by the excessive wear on the carpets in front of such exhibits.

Make Education Fun

While such elaborate equipment is not feasible for the schools, nevertheless, much of the technique of making education fun could be brought to the classroom if the teachers had the willingness and ability to do it. This active organization might do much to further the idea that learning can be fun, to the great benefit of the college, the student and the country.

What I have said thus far applies principally to the primary and secondary grades. What more can be done at the college level?

In former years there was much criticism that an engineering education was too restricted and that graduates were not sufficiently well rounded to progress beyond the narrow confines of the profession. Due to recommendations made by your Society, there are being incorporated in the curriculum certain humanistic-social subjects. These will undoubtedly make for a fuller life and a deeper appreciа-

tion of cultural and spiritual values. If these studies are to be of greatest value, they must be closely integrated to the needs of the engineer.

In later life his salary and advancement will depend not so much on what he knows, as on what he is able to produce for his immediate superior. If he is a good engineer, he will be assured of a steady job, but his promotions will come as he is able to produce more than the company expected of him and as his contributions to its welfare go beyond a routine position.

Second to our need for more engineers is our need for leaders. Some men are born leaders, and many of those with an engineering education rise rapidly to the top. Forty per cent of the principal executives of our major corporations have a technical background, predominating over the lawyer and banker of former years. The administrative ability of the trained engineer is being recognized today and his talent applied to the broad field of management.

But leaders are not being born fast enough to supply the increasing demands of this technological age. We are living in an intensely competitive world, and America can hold its dominant position only by producing more and better leaders to guide our destiny. Here lies a great challenge to the colleges. Potentially, an engineering background affords the greatest opportunity for supreme contributions to our national welfare in whatever field the graduate enters. The college can do much to make that potentiality a reality.

The college can warn the student against the traits of mediocrity. Most people want to be followers; they prefer to take, rather than give, orders. They shun responsibility; they dread making decisions; they watch the clock, rather than put in the extra effort to get a job done; they want security without earning it; they find physical effort preferable to constructive thinking.

The father of a college graduate called up a friend, a railroad president, and requested a job for his son. In a subsequent interview with the president, the boy was asked what he would like to do on the railroad. He wasn't sure, so the president sent him out on the road for a week to look over the various jobs and then come back and tell him what he wanted to do. When the week was up, the young man reported, saying, "You know the man who goes around with a hammer tapping wheels to see if they are cracked? Well, I'd like to help him listen."

In his primary role, the engineer is not a leader, either by training or function. That so many break away from routine to achieve top rank is indicative of the soundness and versatility of a technical training. The colleges have been so intent on making good engineers that they have failed to develop latent talents of leadership. Innate ability or inspiration of the individual, rather than his undergraduate training, has produced the leader.

Sometimes small incidents single out the individual from the mass of his fellows and kindle the spark of leadership. Recognition of a task well done may be just such an incentive. The college should train the engineer to speak well and convincingly in public. It should give him a correct picture of our great industrial empire and what makes it tick. It should not so overburden him with laboratory reports that he feels he cannot spare the time for extracurricular activities. The professor who takes a personal interest in the student can give him an insight into the philosophy of life. He can tell him of the importance of personal appearance and the social amenities. He can fire the imagination with the great opportunities that lie ahead to the one who has the will to achieve.

Engineering Approach

Many of the ills that beset the country today are due to a failure to learn the facts, to analyze a situation thoroughly, and then act on it without fear or favor.

Many of these difficulties would have been obviated if they had been considered by what has been aptly called the "engineering approach." This is a systematic quantitative analysis to determine the relations between cause and effect. The engineer is trained to be certain of his facts and to be sure that he has all of them. He designs with mathematical precision, but has the constructive imagination to foresee difficulties and be prepared to overcome unexpected ones if they occur. He must make ample allowance for factors that cannot be accurately pre-determined. He is trained never to fly in the face of fact through ignorance, cupidity or lack of time or money. He must not gloss over points which affect him adversely or eliminate those which don't jibe with his preconceived ideas. He cannot act on guesses, whims or hunches and he must be without bias or prejudice. He cannot indulge in half-baked dreams or take long chances on unrealistic premises. The engineer has no corner on integrity, but all of his training is designed to make him think accurately and realistically.

If this type of thinking had been applied by our leaders in our diplomacy with other nations, and to the economic and political acts of our government, many of the blunders which have been so costly in lives, dollars, prestige and security, would have been avoided.

The engineer must be trained in public relations that he may go beyond his slipstick and blueprint and take a broader interest in public affairs and his fellow man. He must learn to sell himself in order to render the real service of which he is capable. He must develop better insight into what motivates people to act, he must have the diplomacy to persuade others to think as he does, and he must have a fuller appreciation of human relations.

He who produces the goods and services of our abundant living should be fully conversant with the factors which have made it possible. Too many college graduates have erroneous ideas on big business, mass production, our competitive enterprise system, and private ownership. Unwittingly, they would tear down that which their liberty-loving and industrious forebears have built. They are so sure in their misconceptions. Kettering says, "It is not what you don't know that is harmful, but what you do know, that isn't so." They must be set aright on the fundamentals of our economic system.

More young men and women must be inspired to take technical courses. Emphasis must be placed on the basic sciences in the lower grades, and teachers must develop the technique of making them enjoyable and practical. Courses for engineers on humanistic-social subjects should stress leadership, public relations, and a knowledge of the factors that have made our country pre-eminent. In producing a well-rounded graduate, the college must train him, not only to be a good engineer, but to be a leader as well.

College Notes

G. Stanley Meikle, research director of the **Purdue Research Foundation**, will become vice-president of that foundation July 1, and will be succeeded in the capacity of director of research by Dr. Ralph A. Morgen, who is currently Program Director for Engineering of the National Science Foundation in Washington, D. C. Announcement of the change was made today by President Frederick L. Hovde of Purdue University, who is also president of the Research Foundation. The change was approved yesterday at the annual meeting of the directors of the foundation. Mr. Meikle will succeed Charles J. Lynn, of Indianapolis.

Goals of Research

By L. A. DuBRIDGE

President, California Institute of Technology *

As the title of my remarks suggests, I am not proposing today to argue about the desirability or importance of research, about its cost or about the shortage of research people or research funds. All these things, before this audience, can be taken for granted.

But I am going to take the liberty of reflecting for a few moments on another subject, which possibly should also be taken for granted; namely, the place and purpose of research in science and engineering in an educational institution.

Clearly, in order that my remarks on this subject should make sense, I must explain what kind of an educational institution I am talking about and I must state my own philosophy of what such institutions should be.

Obviously, I am not going to be talking about either public or private elementary schools or high schools, or even junior colleges. Nor shall I try to encompass the problems of the separate liberal arts college. In fact, in order that I may stay within an area which has relevance to the interests of this audience, I shall speak only of such institutions of higher education which are or which include schools (or divisions or departments) of engineering. On the other hand, I shall also exclude institutions—if there be any such—which include within their curricula *no* offerings *other* than those leading to a Bachelor's degree in engineering. In other words, I shall be talking about research in institutions where both undergraduate and graduate work in engineering (and presumably in science and possibly in other fields too) is being offered.

In fact, as you will see, I am really talking about a university in the sense in which that term was used by the Commission on Financing Higher Education; that is, an institution offering graduate work in more than one professional field. (Under this definition, M.I.T., Caltech and Carnegie Tech are universities. A separate law school or medical school would not be.)

Now I must admit that I have a highly prejudiced—almost emotional—feeling about universities. I happen to think that they are just about the most important institutions in the Western World. I believe they have made contributions to western civilization—physical, intellectual and spiritual contributions—which are beyond the power of any man to compute or to comprehend. And I believe that the nature of the civilization that our grandchildren will inherit on this earth will depend in a critical—possibly in a decisive—degree on what our universities do, or fail to do, in coming years.

I believe in this decisive role of the university, not because I deprecate the role of our other educational, religious and political institutions; but I believe that the way in which civilization changes over the centuries is largely determined by how men use their heads. The university, as I view it, is the spearhead of man's efforts to make better use of what is in his head. It is at the university that

* Presented June 15th 1954, at the 50th Anniversary celebration of the founding of the engineering experiment stations at the University of Illinois and Iowa State College, Annual Meeting of A.S.E.E., University of Illinois, Urbana, Ill.

men's intellectual abilities are sharpened and are brought to focus on mankind's basic problems. At the university, man's intellectual forces are mobilized for the attack on those great unknowns which lie just beyond the frontiers of knowledge.

It is the role and the task of the university to be eternally dissatisfied—dissatisfied with man's inadequate knowledge; dissatisfied with the ways in which he uses his knowledge. Thus, the chief aim of a university must be, not merely to help individual men to learn more, but to help mankind to know more.

Research Fulfills Primary Aim

And that is about as succinct a way as I know of expressing, not only the goal of a university, but the goal of research—to help mankind to know more. Research, indeed, is the specific mechanism through which the university seeks to fulfill this primary aim—to enlarge man's understanding of the world, his understanding of his fellow men and of himself.

You will note that I have used interchangeably the phrases, "to know more" and "to understand more." I do this without apology—and, in fact, with emphasis. To know and to understand are not quite synonymous. For, though one can normally not understand without knowing, we frequently know things we do not understand. Yet the goal of science must be not merely to acquire knowledge for its own sake, but to secure knowledge as a step toward understanding. A research project collects facts, experimental data, not solely to prepare tables of numbers, but as an aid to finding or perfecting a theory, an interpretation, an understanding of the phenomenon. Furthermore, we must be most exacting in determining how far understanding has been achieved. In the field of science we require that understanding shall be quantitative, not merely qualitative, and that it lead to the ability to *predict*. We require that our theory explain *all* the related facts, not just some of them, that it describe accurately *in advance* all experiments which we perform. We also aim for theories which have simplicity, elegance, beauty. Reaching an understanding of things not only satisfies an intellectual desire, but an emotional or aesthetic one too.

In short, then, if the goal of a university is to help men learn more and to help *man* understand more, then the place and purpose of research becomes obvious. Research is essential to the fulfillment of the university's mission. However, the research undertaken must be devoted solely to achieving that mission—achieving understanding.

Now I think it is unlikely that anyone here will quarrel seriously with what I have just been saying. I would probably do well to drop this discussion right at this point while our minds are still on high minded principles on which we all agree, and let each individual and each institution reach his own conclusions as to how to carry the principles into practice. However, I know that engineers are "practical" people and so I shall go a step further and expose some of my own prejudices on the practical applications of these principles. Here we may tread on delicate ground—but with your permission, I will tread anyway.

What ideas do these general principles suggest in regard to the research program in a school or college of engineering? I suggest that they lead to at least three useful rules.

Maintain Close Tie with Basic Sciences

Rule One: Maintain a close tie with the basic sciences. An engineer, after all, is someone who is putting to practical use today what some scientists discovered yesterday. It is pretty likely that the scientists may have a pretty good grasp of what they discovered and their knowledge and understanding will be useful in developing applications. Still more important, the engineer is interested—or should be—in the new practical applications of tomorrow. These will depend on what the scientist is working on *today*.

Now I know the disdain that many engineers have for physicists. They are such impractical guys. Why don't they work on something useful? I'll return to this question later, but right now I'll only say that if the engineers during the 30's had only absorbed a little more of the impractical work of the nuclear physicists, there wouldn't be so much nonsense in the air today about nuclear power. The sooner the engineers take over this field, the better. The physicists have a bear by the tail and they would like to get rid of it. Fortunately, there are a few good engineers getting into the business. But the rate at which new ones are being trained—adequately trained—is so low that it will be 20 years before the engineers are really ready to take over. In the old days a 20-year gap between the physicist and the engineer was not so bad. But things happen faster now and the transition should take place more quickly. For this reason, the engineer who is attempting to carry on scholarly work or research is missing an opportunity if he does not keep in touch with the physicist, the chemist and even the biologist. Needless to say, he ought to pass on what he learns to his advanced students.

What are the fields of physics today that will be of engineering interest tomorrow? I don't know! No one knows. That's what makes engineering so much harder than physics. The physicist can go gaily on looking for new things in any field that amuses him. The engineer has to guess which new things he will *wish* he knew about five or ten years from now.

However, it isn't really that bad. Fertile and promising fields are reasonably obvious. For example, if the engineer keeps his eye on the fields of nuclear physics, the solid state, low temperature physics and microwave spectroscopy, he will have pretty good insurance for the future. In any case, more collaborative research programs between engineers and physicists would be a fine thing. Similar collaboration could also be productive with chemists, mathematicians, geologists and geophysicists. No individual or department, of course, can cover all these areas. But if each person covers one, then all will be covered.

Stick to Fundamentals

Rule Two is closely related to Rule One. If the goal of university research is understanding, then this research must not only keep in touch with the basic sciences from which it springs, but it must also itself *stick to fundamentals.* It is too often assumed that, since the job of the scientist is to do "basic" or "fundamental" research, therefore the job of the engineer is to avoid this and to invent gadgets. This is, of course, nonsense. The engineer *in a university* has just as much obligation to stick to the fundamentals in his field as the chemist or physicist in his. The university civil engineer is not concerned with designing just another bridge or dam, but with developing new practices, new principles, new materials, new methods of structural design. The mechanical engineer does not simply invent an improved governor for a steam engine; he tries to advance understanding of thermodynamics, of solid and fluid mechanics, of the structure of matter, the nature of vibrations, of fatigue, etc., etc.

The university engineer is thus in an extremely critical position, intermediate between the pure scientist on the one hand and the industrial designer or inventor on the other. To some extent he does the things which the industrialist thinks the scientist ought to do—but which the scientist has lost interest in. The physicist is engrossed in the problems of nuclear forces; who is going to develop the fundamentals of nuclear technology. It's a long step from Fermi's first chain reaction to the first economical power plant—and lots of room in between for fundamental engineering research. The same is true in any field. Isn't this the proper place for university research in engineering?

This leads me to *Rule Three:* Be sure

that the goals of sponsored research and unsponsored research are the same.

Here, of course, I enter a large subject which I cannot possibly take time to explore adequately. But it is worth emphasizing that if the goal of research in a university is *understanding*, then this goal is equally valid regardless of who is paying for the research. It is true that the degree to which a university can advance toward its goal of understanding will depend upon the availability of funds. But no funds should be large enough to purchase a deviation, delay or abandonment of that goal. The university is not a supermarket where a customer should expect to find any article he wants. It is not a job-shop, prepared to turn out a custom-built gadget for each and every comer. A university is not even a bank which likes to handle money just for the sake of handling money. When money diverts effort from proper goals, then the university is literally being robbed—no matter how much "overhead" allowance is attached to the contract. A big budget which is buying things the university has no business selling is a sham—and the real university may be suffocated under the load of padding it is forced to carry around.

Gift Horses Should be Looked in the Mouth

It is high time, for example, that universities ceased the practice of accepting any and all gifts or contracts—just because they appear to come "free." Gift-horses most emphatically *should* be looked in the mouth. I know of a college that once accepted a gift of an enormous collection of stuffed birds. Now it is stuck with the job of taking care of them, and, in order to use them, they hire someone to give a course in ornithology—a course which that college, desperately short of funds to teach history and physics, has no business giving.

I have heard of another institution in which half the electrical engineering department is busily engaged in designing radar antennas—not because they are seeking to understand the radiation of electromagnetic waves, but because an Air Force contract for such gadgeteering was available. The excuse was that they could hire three more engineers that way and these men sometimes helped with the teaching. On the same principle, I suggest that the college lease and operate a five-and-dime store, so that the people who work in it can also, on the side, teach economics, marketing, human relations and business English.

I am just as cognizant as anyone of the problems of financing higher education. I spent four years working on a Commission which studied the subject. We didn't find any easy answers. But I did not become convinced that the problem would be solved by financing things that were *not* higher education.

I must, of course, at this point recognize that, for better or for worse, the modern university has committed itself to carry on activities which do have little relation to higher education. The state universities render a variety of services to the agricultural community which might be more appropriately handled by some sort of farm bureau. And other local services have been assumed in special cases. Most important, the universities have been called upon, and have patriotically and properly responded, to help the national defense in time of emergency. The contributions which universities have collectively made in this area are beyond calculation.

But we should not be led into thinking that designing weapons of war is a normal and proper function of a university as a university. It is an emergency function rendered, in part, because special technical talents are available in universities, and, in part, because certain administrative problems are avoided and because better people are attracted to university operated laboratories. I believe there are sometimes even indirect benefits to the teaching or research program of the institution. If the project—

which is usually "secret"—can be housed and operated far from the campus as a separate establishment, it is possible that no harm will ensue.

But we should not confuse the operation of special facilities or services for the government as a contribution to national defense with the normal educational functions of a university. Take on these extra services, by all means, when it is necessary or desirable or patriotic to do so. But get rid of them too, when possible. And in any case, in times of peace, they must not destroy the major functions of a university for they are important to national defense too.

On the other hand, we must hasten to point out that the normal, proper goals of a university can often be advanced by federal funds under research contracts or grants. I am all in favor of agencies like the National Science Foundation, the Public Health Service and the Office of Naval Research supporting research programs in science and engineering which the universities themselves originate as a desirable part of their programs. This is fine and there should be more funds available for these agencies to use in this way.

All I am saying is that a proper research program in any field should not be abandoned or distorted or harmed by taking on irrelevant work for which funds happen to be available—and then pretending that this irrelevant work strengthens the program which it has damaged or displaced.

I said a few moments ago that understanding should be the goal of research no matter who finances it. Let me now add that when care and firmness and patience are exercised, financing can be found from many sources—private, governmental, industrial, state—to support research which does lead to understanding.

Research and Education

I return now to a matter which has, no doubt, been bothering many of you as I have been talking about research and education. I have used these terms almost interchangeably. I have spoken of research as a part of the function of higher education. I could equally well have spoken of education as a function of research. Some of you may be wondering whether I haven't heard about the conflict between teaching and research. How every faculty member and every institution must decide how many of its hours and of its dollars must go to teaching and how much to research.

The answer is "No—I haven't heard of the conflict." I have heard a lot of argument, but none that convinces me of a real conflict. If the purpose of a university is to advance understanding, then it follows that both the understanding of the student and of the teacher ought to go together. How a man can really teach science or engineering without acquiring a consuming curiosity about the many things that are unknown is beyond me. And how one can get a glimpse of the unknown without an equally consuming desire to tell it to others who will carry it on is also a mystery. An inquiring mind must be the chief possession of university people—and that's the only kind of a mind that can either explore the unknown *or* stimulate students. I think history has shown that with but few exceptions, research laboratories go dead when not stimulated by the continued intrusion of fresh young minds. And teaching establishments also go dead when not infused by the inquiring spirit of scholarship.

And let that be the fourth and final rule that emerges from our look at the goals of research: The student is the best friend a research man ever had—and vice versa!

Vast Public Relations Job is Necessary

In conclusion, I must express dismay at the vast public relations job to be done—with our students and with the general public. Why is it that there has grown up the widespread impression that science and gadgeteering are the same thing? Why is it that so many people—including some in industry and some in government—believe that the universities

are in the business of making and selling gadgets? These same people have often heard that universities need money. So they naturally conclude that by buying a gadget from a university, they kill two birds with one stone—they get the gadget and take credit for helping the university. How can we correct these impressions?

Possibly we have overemphasized the gadgets—including the weapons—that flow from science and technology. Possibly we need to get back to fundamentals in our public relations too. Possibly it's time to tell the world that the main purpose of science is not to produce bombs and guns and radar—or even refrigerators, radios and color TV. Possibly we should come out boldly and unashamedly and tell the truth—the aim of the scientist and engineer is to advance human understanding. We believe in human understanding for its own sake. We believe humans differ from the beasts largely in their ability and their urge to learn, to know, to comprehend. Men climb Mt. Everest, explore the bottom of the sea, sail to the far corners of the earth, explore the atom, the crystal and the stars—all because they are born explorers—because men are always challenged by the unknown.

And what good is understanding? Well, aside from the fact that we are unsatisfied without it—aside from the fact that intellectual achievement possesses beauty and elegance which is good for its own sake—understanding leads to advances in human welfare. It abolishes ignorance and fear. It enables us to replace the muscular efforts of slaves by the energy obtained from burning coal. It enables men to avoid cold and hunger and suffering and disease. Are science and engineering just the tools for man's amusement and for his ultimate destruction? Let us say rather—and more truthfully—that they are his chief tools in his eternal struggle to achieve his highest moral and spiritual ends.

In the News

The Chemstrand Corporation, in production since December, 1953, now is operating as the first wholly integrated nylon manufacturing facility in the United States, Henry H. Bitler, president, announced today.

Pioneering aerodynamics research at airflows well above the supersonic is being carried out in the Guggenheim Aeronautical Laboratory, **California Institute of Technology** (GALCIT), it was reported today. GALCIT scientists are investigating, experimentally and theoretically, how air flows around a body at hypersonic, or faster-than-supersonic, speeds. They are using two hypersonic wind tunnels, one of which has now achieved a speed about eleven times that of sound, or Mach 11. (Mach 5 is arbitrarily taken as the beginning of the hypersonic range.)

Alfred C. Ingersoll, assistant professor of civil engineering at the **California Institute of Technology**, has been appointed a Point Four Program specialist in engineering fluid mechanics to serve at the Bengal Engineering College in India, it was announced today.

He has been granted a leave of absence by the Institute Board of Trustees to serve in this capacity. He will aid in establishing a fluid mechanics laboratory for both research and instruction at the College, located at Sibpur, India.

Interim Report of the Committee on Evaluation of Engineering Education*

Objectives of Engineering Education and Their Implementation

Foreword

The ASEE Committee on Evaluation of Engineering Education was appointed in May, 1952, by President S. C. Hollister. The charge to the Committee was to determine the pattern or patterns that engineering education should take to keep pace with the rapid developments in science and technology, and to educate men who will be competent to serve the needs of and provide the leadership for the engineering profession over the next quarter-century.

The Committee on Evaluation began its work in June, 1952, at the Dartmouth meeting of the ASEE. The Education Committee of E. C. P. D. immediately requested the Committee to give consideration to the development of standards that might aid E. C. P. D. in bringing engineering accreditation in consonance with future responsibilities of engineers. The Committee on Evaluation was asked particularly to clarify the curriculum content that differentiates engineering education from that in science or in technology.

In order to enlist the aid of engineering educators throughout the United States in this important undertaking, the Deans of all engineering colleges having accredited curricula were invited to appoint Institutional Committees to conduct their own studies on evaluation of engineering education. A series of questions, based in part on previous evaluation studies as outlined in Appendix A, expressing the broad problems confronting engineering education, was sent to all of these Institutional Committees to form the basis of exploration. The discussion of these questions by the Institutional Committees and the ASEE Committee culminated in the preparation of a series of institutional reports and in the Preliminary Report which was issued in October, 1953.

This Preliminary Report was distributed for critical review to all colleges with accredited engineering curricula. Reports embodying the criticisms which developed were then prepared by the Institutional Committees. The extraordinary response of the institutions in reporting their views resulted in an extended and penetrating analysis that was nation-wide in scope. The recommendations contained in these 122 reports were studied by the main Committee. Many of these recommendations, together with those of the Committee itself, now form the basis of this Interim Report.

The Committee wishes to express its grateful appreciation to all those on the Institutional Committees whose efforts have made this coordinated study possible. It has made free use of the ideas and of the particular phraseology of individual institutional reports without citing specific references. Not all of the recommendations from institutional reports could be incorporated in this Interim Report, but the dominant issues were included. However, the analyses presented in these institutional reports aided the Committee in understanding the nation-wide thought of engineering educators.

Because of the long-range importance of this study, the Committee concluded

* Presented at the Annual Meeting of ASEE, University of Illinois, June 15, 1954. This project was financed in part by contributions from the constituent societies of ECPD, the Engineering Foundation and the General Electric Company.

that this report should be submitted as an Interim Report, so that it may be reviewed critically by the Society and further revised in the light of such an appraisal.

In view of the significance of graduate study, the Committee has recommended that a comprehensive investigation of the evaluation of graduate study in engineering be undertaken by ASEE. It is understood that this will be done and for that reason graduate study is not treated as adequately as it otherwise would be in this Report. The evaluation of the influence of humanistic-social studies upon engineering education is presently being conducted by a special committee of ASEE. Hence this subject is treated broadly rather than in detail in this Report.

The Committee wishes to express its appreciation to the Engineering Foundation, the constituent Societies of E. C. P. D. and the General Electric Company for the financial assistance which made this study possible.

Objectives of Engineering Education

The determination of the pattern which engineering education should take in the future must, of necessity, be based upon the obligation of the engineering profession to society, and on the importance of the development of the student as an individual. The obligations of an engineer, as a servant of society, involve the continual maintenance and improvement of man's material environment, within economic bounds, and the substitution of labor-saving devices for human effort. Moreover, he is at all times responsible for the safety of people, and his activity usually has a direct bearing on the welfare of large segments of society. Like the physician, the engineer must work within the current limitations of the state of his art, and decide which of several possibilities provides the best solution to a given problem.

The state of engineering is far from static, for engineering is essentially a creative profession. It has played a dominant role in building American industrial superiority, in developing the principle of mass production, and in giving the American people their high standard of living. The extension of our knowledge of basic science has opened doors to vast new areas of engineering endeavor, and has expanded the foundations underlying many of the existing engineering fields. Some of the newer fields of engineering have been reasonably alert to assimilate new scientific advances into their teaching programs. Throughout the past half century there has been a continuous reappraisal of engineering education, with introduction of new material and substantial shifts of emphasis to keep it responsive to the needs of the profession. The response of engineering educators to the challenging developments of modern science will have a vital influence upon the course of engineering progress in this country.

Any attempt to specify the content of an engineering curriculum must be preceded by the development of a clear understanding of the objectives of such professional education. These objectives are two-fold and are based on the technical and social responsibilities that must be assumed by graduates electing to enter the profession. The entire professional educational process is more inclusive in scope than a four-year engineering curriculum, for it also includes training in high school and post-graduate study in a university or in industry, along with continual self-study and engineering practice before full professional status can be achieved. The first objective, the technical goal of engineering education, is preparation for the performance of the functions of analysis and creative design, or of the functions of construction, production or operation, where a full knowledge of the analysis and design of the structure, machine or process is called for. It also involves mastery of the fundamental scientific principles associated with any branch of engineering,

including a knowledge of their limitations and applications to particular problems, such as the development of materials, machines or structures, as well as the ability to make critical analyses and to organize these into convincing oral or written reports.

The second objective, the broad social goal of engineering education, includes the development of leadership, the inculcation of a deep sense of professional ethics and the general education of the individual. These broad objectives include an understanding of the evolution of society and of the impact of technology on it; an acquaintance with and appreciation for the heritage of other cultural fields; the development of a sense of moral and ethical values consistent with a career as a professional engineer; and finally, the development of a philosophy which will insure a personal satisfaction in the pursuit of a productive life.

Implementation of the Objectives

A number of factors influence the effectiveness of engineering education. Of these, faculty and curriculum have received the greatest emphasis in the nation-wide discussions that have taken place, and they form the central theme of this Report. However, admission requirements, high school-college articulation, existence of adequate facilities, provision for gifted students and the integration of graduate programs will also be considered. All have a bearing on the implementation of any suggested changes in present programs. Nevertheless, thoughtful consideration inevitably leads to the conclusion that the character and quality of the faculty are of controlling importance; therefore, the selection and development of the faculty will be considered first.

The Selection and Development of an Engineering Faculty

The existence of outstanding faculties is far more important to the advancement of engineering education than details of curricula or the magnificence of facilities. The university is a community of scholars and as such requires outstanding teachers to attract outstanding students. To improve and develop courses or curricula, to build up facilities, in short, to attain prestige as an educational institution, all require a faculty of competent teachers and scholars.

A thoroughly competent faculty can be acquired and maintained only if the college administration gives careful and discriminating attention to the important problems of recruitment, selection, training, advancement and termination of employment.

University and College Environment

The academic and professional development of an engineering faculty can proceed only in a favorable environment. Although the environment includes the physical surroundings, the more important part is the intellectual atmosphere; that is, the attitudes and ideas of the people who comprise the university. In such an atmosphere there should first be unity of purpose, the mutual selection of common goals and the collaboration of effort toward their achievement. There must be opportunity and encouragement for intellectual growth and professional development. Teaching loads must be kept at reasonable levels if time for scholarly or creative activities is to be available. The development of a favorable academic atmosphere should be the concern of all faculty members, particularly those in senior administrative posts.

Physical surroundings also contribute to a favorable environment. Facilities may be modest or extensive, as long as they are in harmony with and adequately serve the curricula. Besides adequate class rooms and laboratories, the individual teacher needs appropriate office space, research facilities, technical services, secretarial help, and an adequate library. The extent of the li-

brary, its accessible location and required use are essential elements in any educational process.

The atmosphere of a university is also a significant factor in student progress. Students need a close bond of mutual interest and friendship with members of the faculty. They need objective guidance and encouragement in their intellectual growth, they need sympathetic understanding of their personal problems, but above all, they need the realization that they are being treated as individuals. A faculty which is genuinely concerned with these responsibilities is most likely to create a favorable student environment.

Qualifications of Teachers

The engineering teacher must have a full appreciation of the goals to be achieved. He should realize, first of all, that a course can be taught either as a narrow specialty or as a liberal subject in a professional curriculum, and strive for the latter. Such a liberal course is one in which the teacher inspires his students toward creative endeavor and intellectual development not only while in college but throughout their careers. It is one into which he brings recognition of the importance of intellectual honesty and professional integrity. To achieve these goals he should be endowed with energy, enthusiasm, and a sincere interest in the development of men. To be fully successful he must exercise judgment and tact, and have the ability to meet the minds of his students. He should perform creative work whether it be in teaching, writing, research or professional activities.

The selection of individuals for faculty appointments requires the evaluation of their qualifications. Good teachers have always been personally creative and able to inspire their students to creative endeavor. In the past, they necessarily emphasized the art or practice of engineering. However, during the lifetime of present faculties the art of engineering has come to depend greatly upon the basic science of engineering. It must also be recognized that the universities are better equipped to teach the science underlying professional practice, whereas industry is better adapted to provide experience in practical applications. Within a faculty there should exist a balance of experience in both the science and the art of engineering.

For a relatively young candidate for a faculty position, the strongest evidence usually available to measure probable creative ability in teaching and research is an educational background which includes the doctor's degree. For experienced persons, evidence of the capacity of the individual for creative teaching and research may be gauged by other criteria, and the formal educational background is of less significance.

Young engineering teachers who hold only the bachelor's degree should be employed only in a temporary position that presupposes continuation of education. Lack of such progress should be sufficient reason for termination of such an appointment.

Appropriate industrial experience is important in a well-balanced faculty. This experience may be considered in the selection and advancement of individuals, but it should not be a requirement for faculty members with special educational background or with demonstrated creative ability in research or teaching. Every teacher should become a recognized expert in his field regardless of his background. There is no substitute for knowledge of subject matter far beyond the limitations of that to be taught. However, it is recognized that mastery of subject matter alone will not guarantee good teaching and neither industrial experience nor advanced degrees in themselves are adequate criteria. The minimum essentials for good teaching are the mastery of subject matter and the capacity of the teacher to draw students into active participation in the learning process. Strong individuality is often

characteristic of distinguished teachers, but the capacity to cooperate with colleagues in effectuating the institutional program as a whole is nevertheless of great importance.

This short discussion of the desirable qualifications of a good teacher is amplified in an informal letter from a regional chairman of E. C. P. D. to a college president, which is reproduced in Appendix B.

Recruitment of a Faculty

Of paramount importance to any profession is the personnel of that profession. No time can be spent more profitably than that required for the recruitment and development of competent teachers. Recruitment of a faculty embraces the contacting of persons whose aptitudes, abilities, and personalities are of the desired type; telling them of opportunities, environment, obligations, and limitations of the profession; ascertaining whether their ideals and ambitions are consonant with those of the profession and the school; and finally arranging suitable compensation for employment.

New teachers are often those who have just finished study of a part of the wide field of engineering and science. It is recommended that promising undergraduate and graduate students be sought out and their aptitudes appraised as potential teachers early in their schooling. If a student's interest is aroused in a teaching career, his study may be guided to embrace breadth of view and scholarly attitude. Such a program should help to recruit and develop teachers who will carry the responsibility for improvement of engineering education to meet the needs of the future. Care should be exercised to avoid excessive inbreeding; a heterogeneity of faculty backgrounds is inherent in the very concept of a university.

The effective recruitment and retention of a qualified faculty can be insured by the establishment of a salary scale in colleges of engineering comparable to that earned by outstanding practicing professional engineers, as indicated by the published surveys of national societies. The example of accepted practices in establishing adequate faculty salary scales in the profession of medicine and law is offered as evidence that competitive situations must be met if professional education is not to stagnate.

Development of a Faculty

Even though the environment and salary scale of an engineering college may be such as to attract and retain an outstanding faculty, the newer members of such a group will usually need guidance in the techniques of teaching. Their study of the ASEE Report on the Improvement of Teaching should enhance the effectiveness of their teaching materially. The primary purpose of an engineering college is to provide effective instruction in subject matter through the stimulation and motivation of students, and it is essential that those selected to teach be trained properly for this function. Their own use of and insistence on the use of good English, both oral and written, should be considered as an essential part of their teaching of any subject.

Although experienced teachers will generally perform more effectively than young instructors or graduate assistants, it is possible to achieve excellent results with the latter, provided they are effectively supervised. Furthermore, teaching is a beneficial part of the educational experience even for those who later elect industrial pursuits. Seminars, discussion groups, formal and informal conferences between experienced and inexperienced teachers can all be used effectively for the development and growth of a faculty. Informality in such arranged programs has merit as long as it does not encourage the development of irregularity of participation. Such programs must be varied in form to maintain interest.

It is important that faculty members set an example for their students by their membership in professional and technical societies, attendance and active participation in society meetings, study of current literature, and interest in new developments or research. Such leadership among faculty members is particularly necessary in institutions that are able to provide only limited opportunities for research, for it contributes an important element of vitality to undergraduate teaching. The spirit of leadership that inspires the student to want to lead is of great importance. It can be developed by teachers who are men of stature, judgment, wisdom and tact. The ambition for leadership should involve not only ascendence in a man's technical field, but should include service to society as well.

In engineering teaching, continual contact with the forefront of engineering and scientific progress is essential. Leadership in scientific and engineering progress has frequently stemmed from university research activities. The engineering teacher carries a responsibility to contribute to the advancement of knowledge through engineering research. The university must provide the opportunity in terms of time, facilities and assistance to realize this objective.

It is only when teachers of professional subjects are recognized as experts that they have an opportunity for consulting work. Hence, the privilege of such consultation is not considered to be a major factor in recruitment of young teachers. Consulting practice should be considered as a means of developing and further strengthening an engineering faculty. Close association with engineering work or research in industry should stimulate the teacher and improve his teaching. Consulting is also a source of ideas for research. The limit upon the useful extent of this activity has not been determined. However, the belief is widely accepted that an average of one day per week of the individual's time devoted to consulting activity will reflect to the overall advantage of the institution, provided such consulting is of a high professional character.

Faculty members engaged as principals in consulting work must be registered professional engineers or the range of their practice will be restricted. Some younger staff members should be encouraged to become licensed. This statement should not be interpreted as applying to those faculty members engaged in engineering science instruction, research or similar activities.

Evaluation of a Faculty

Evaluation of the potential of prospective faculty members, and of the achievement of existing staff, ranks with the development of a progressive atmosphere as a most important function of a university administrator. Systematic rather than haphazard methods are essential as a guide for recruitment and for making salary adjustments and promotions. Definite policies on termination of employment for those who do not live up to their expected performance are also necessary for proper development of a strong faculty.

It would be most desirable if this evaluation could be done on a quantitative basis, but the Committee is not aware of any systems which warrant recommendation for general adoption. It suggests that there be more experimentation by individual institutions in the development of quantitative systems of faculty evaluation. Any evaluation system must serve only as a partial guide, since personal judgments must remain the most important factor. The Committee recommends that such quantitative systems as are developed be reported at meetings of the Society and in the Journal. The success of some industrial evaluation systems indicates that there is hope for real progress in this area.

The fact that evaluation of the progress of a faculty member must be based

on judgment involving many factors, indicates that administrators at each level should inform themselves of the viewpoints of their faculties before reaching these judgments, realizing that there are dangers in judgments made by associates of the individual concerned. In particular, the faculty should be as completely informed as is possible concerning the methods used in evaluation.

Evaluation, to be effective, should be as objective as possible, and it should include along with other factors all the items mentioned in the section on the Qualifications of Teachers with emphasis upon:

a. The effectiveness of the individual's teaching based upon knowledge of subject matter, intellectual capacity, quality of judgment, professional and personal stature, and qualities of personal leadership as shown in his ability to inspire students.

b. His productivity in research and other creative areas including new methods of presentation of his subject matter.

c. His activity in professional societies, government and community affairs.

d. The nature and responsibility of consulting services to other areas of the university and to outside organizations.

e. His publications.

f. His professional development as evidenced either by progress in early years toward advanced degrees, or later by his attainments and recognition as a scholar in his field.

It is important that administrators advise members of the staff periodically regarding their standing, particularly those who should be encouraged at an early date to abandon a teaching career. Mere lack of promotion or salary advances should not be assumed as a sufficient method of criticism for individuals who are not developing according to the standards expected.

It is equally important to stimulate the good teacher by verbal or written approbation either for general progress or for special accomplishments. It is essential that those staff members endowed with energy and enthusiasm combined with high technical ability that is applied in a creative manner be compensated to the fullest measure.

An adequate staff either in a departmental faculty responsible for a curriculum or in a major supporting group, will have at least one in every five who has attained professional distinction. Such individuals will (1) be conducting high grade research of an engineering or educational nature, or other creative activity including publishing of a good quality, (2) be engaged in consulting work at a creative level, (3) be exercising leadership in scientific, educational, and professional societies, or preferably (4) be serving in a combination of such activities.

Curricular Content as Related to the Objectives of Engineering Education

Instructional Goals

The ultimate goal of engineering education is the development of able and responsible men fully competent to practice on a professional plane, especially those who will eventually lead the profession to new heights of accomplishment through creative practice or research. The student, not the curriculum, is the primary concern, yet the curriculum has an important influence on education. Before considering curricular components, the instructional goals toward which they are directed should be examined.

The instructional goals of engineering education include helping the student to learn to deal with new situations in terms of fundamental principles, on his own initiative, and with confidence and sound judgment. The goals should include motivation to keep abreast of the new developments in science and technology, and to continue to grow intellectually in

both professional and cultural areas throughout life.

In professional engineering practice the "new situation" often involves social and economic as well as technical elements and these are not entirely separable. Thus the end result is not merely the numerical solution to the technical problem, but is rather a decision based on a value judgment to which the quantitative technical result contributes one important element. In fact, the significant problems involving engineering seldom occur in well-defined form. Hence, the initial stage of thinking is often an intuitive groping to identify specific component problems. Their solution, in turn, requires the application of thoroughly understood fundamental principles and well-ordered analytical thinking in defining the problem, planning its simplification without losing its essential nature, conceiving a method of attack, carrying the study through to a successful conclusion, and checking the results at each stage. This technical solution is then available to guide the broad decision based upon many other values in which the engineer may participate to the extent that his perspective and judgment extend beyond purely technical matters.

Engineering educators must never lose sight of the broad issues with which large engineering problems are always associated, but it must be recognized that the ability to deal with such broad issues comes only with experience and maturity in the years after college. The importance of keeping such economic and social ideas before students by example cannot be overemphasized. Such concepts should be encompassed even though the main effort at the undergraduate level is largely restricted to developing the student facility and power in the scientific and technical aspects of engineering education. In what follows, therefore, these disciplines are emphasized even though they are but a portion, albeit a vital one, of the total education that the successful engineer acquires in college and throughout his subsequent professional career.

The evolution of engineering curricula has been characterized by a continuous process of invasion of new scientific and technological knowledge. Such innovations have necessitated the development of new concepts or shifts to more fundamental and scientific approaches. It seems evident that the frontiers of science and technology are advancing at a more rapid rate now than at any previous time, and that many of today's frontiers will be reduced to significant engineering practice in the years ahead. Furthermore, these newly developed frontiers illuminate the older fields with new concepts and rejuvenate them with increased vitality. It is a responsibility of the engineer to recognize the new developments in science and technology which have significant potentialities in engineering. Moreover, the rate at which new scientific knowledge will be translated into engineering practice depends, in a large measure, upon the engineer's capacity to understand the new science as it develops.

This translation of new scientific developments into engineering practice will be facilitated by emphasizing unity in scientific subject matter. For example, there is a great deal of similarity both in conceptual understanding and in analytical methods among the generalizations of heat flow, mechanics of fluids, electromagnetic fields, and vibration theory. When a student understands these generalizations, he has gained a concept of systematic orderliness of many fields of science and engineering which enables him to approach the solution of problems in widely diverse fields, using the same analytical methods. This unification of methods of analysis can be accomplished to a considerable degree without reaching beyond undergraduate mathematical levels. It can be accomplished to an even greater degree by

utilizing advanced mathematical concepts.

Looking at the subject of instructional goals even more broadly, one must conclude that the engineer should be a well-educated man. He must not only be a competent professional engineer, but also an informed and participating citizen, and a person whose living expresses high cultural values and moral standards. Thus, the competent engineer needs understanding and appreciation in the humanities and in the social sciences quite as much as in his own field of engineering. He needs to be able to deal with economic, human, and social factors of his professional problems. His facility with, and understanding of ideas in the fields of humanities and social sciences not only provides an essential contribution to his professional engineering work, but also contributes to his success as a citizen and to the enrichment and meaning of his life as an individual. Thus, instructional goals include motivating students and providing them with stimulating opportunities to gain understanding and appreciation of our historical and cultural heritage. This requires that the faculties of the humanities and the social sciences regard teaching engineering students as challenging and rewarding, and also that every engineering faculty adopt an appreciative and understanding attitude toward his colleagues in the liberal arts.

It is also clearly recognized that many engineers progress into managerial and top executive positions in industry and government. For such individuals, the foundation should be laid in college for an understanding of human relationships, the principles of economics and government, and other fields upon which the engineering manager can build. This foundation may be built more solidly in humanistic social courses than in highly applied studies in management.

Education for the profession of engineering does not stop with the acquisition of a degree; it must continue throughout life. The most important goal of engineering education is to motivate the student to learn on his own initiative.

Curricular Areas and Content

The preceding discussion of instructional goals clearly indicates that certain curricular areas are obviously basic to undergraduate engineering education. These areas include mathematics, physics and chemistry, the engineering sciences, the application of these to the analysis and synthesis of engineering systems within the major field, technical courses outside the major field, and humanistic-social studies.

In the following paragraphs, the more important components of an engineering curriculum are described briefly, together with a rough indication of the broad curricular content and approximate level that appear to be appropriate to an undergraduate curriculum. These are not intended as a statement of rigid requirements since the Committee recommends widespread experimentation. However, significant departures should be accepted on the basis of clearly stated objectives rather than on the maintenance of a traditional approach.

Mathematics—Casual perusal of professional journals is sufficient to show that all branches of engineering are continually becoming more dependent upon mathematics of an increasingly high level. Although mathematics can never take the place of engineering judgment, such judgment is more and more often guided by mathematical analysis, and such analysis is rapidly expanding the demands it places upon advanced areas of mathematics. At the undergraduate level, competence in the theory and use of simple ordinary differential equations and their application to the solution of physical problems lies close to the boundary of minimum acceptability of mathematics in any satisfactory engineering curriculum. For students whose interest will be centered in research, development,

or the higher phases of analysis and design, or who contemplate subsequent graduate study in engineering, additional mathematics may be both desirable and necessary.

A minimum level of performance in mathematics should be established whether it be obtained in required mathematics or in engineering courses. However, few engineering courses are taught in a manner to make a significant contribution to the student's knowledge of basic mathematics, nor is time available for this purpose. The engineering sciences and subsequent professional subject matter should be developed by making effective use of such mathematical proficiency, and should be taught by staff members competent to do so.

Physics—Too often the physics taught to engineers fails to embody the many revolutionary new concepts that have been developed during the past generation that are today strongly influencing engineering practice. Modern physics, including nuclear and solid state physics, should be a part of undergraduate engineering curricula. The customary duplication between classical physics and the subsequent engineering sciences of mechanics, thermodynamics, and electricity serves a useful purpose only when it is consciously designed to achieve the recognized pedagogical values in repetition. The American Association of Physics Teachers has undertaken to investigate the problem of teaching more advanced physical concepts to engineers. Every effort will be made by the ASEE to cooperate fully in any proposed study of this problem.

Chemistry—Chemistry should include topics in inorganic, organic, and physical branches presented in condensed and general form. The initial study must prepare engineers to enter advanced courses in chemistry and in applications such as properties of materials, metallurgy, fuels and combustion, corrosion and industrial chemical processes. Hence, such subjects as rates and kinetics of chemical change, chemical equilibria, phase diagrams, solutions, electrochemistry, and colloids should be included. As the content of the subject of engineering physics is revised, careful coordination should be effected between modern physics and chemistry. For studies beyond the usual freshman chemistry course, it is felt that other than chemical engineers may need only a speaking acquaintance with organic chemistry but a working knowledge of physical chemistry.

Engineering Sciences—The engineering sciences are here defined as (1) Statics, (2) Dynamics, (3) Strength of Materials, (4) Fluid Mechanics, (5) Thermodynamics, (6) Electrical Circuits, Fields and Electronics, (7) Heat Transfer, (8) Engineering Materials, and (9) Physical Metallurgy. Few existing engineering curricula contain all of these engineering sciences despite wide agreement as to their basic desirability. It is believed that this degree of breadth is highly desirable in practically all engineering curricula, and that the omission of any of them is a significant loss that should be accepted only for compelling reasons. However, there may be some curricula for which applied sciences other than those listed may be desirable. For example, aerodynamics or possibly a life science or an earth science might be more appropriate for some curricula.

In these engineering sciences, full use should be made of the prerequisite mathematics, physics and chemistry, recognizing that repetition is a normal pedagogical necessity, but that it can be most effective only when consciously and purposefully used. Perhaps nowhere else can the qualities of a scholarly engineering faculty be employed so effectively as in the presentation of these engineering sciences with an appropriate mathematical understanding.

Engineering Analysis and Design—Education directed toward the creative and practical phases of economic design, involving analysis, synthesis, develop-

ment, and engineering research is the most distinctive feature of engineering curricula. Such education intrinsically stems from the case method of approach, rather than as an orderly exploration of a given subject matter field. Some experience in this "design" function should be carried in an integrated manner through each semester of the last two years and begun earlier if possible. Among various mechanisms for implementing the case method are: theses, projects, group operations, competition between groups, the use of realistic industrial or unsolved problems, examinations on unfamiliar subject matter, and synthesizing a new device rather than analyses of a given device. These case studies go far beyond, and are quite different from routine repetitive features of practical design, the use of handbooks, or the mere description of structures, equipment or machines, including their construction, operation and maintenance. Such engineering art is learned more effectively from field experience than from college study.

The capacity to design includes more than mere technical competence, and involves a willingness to attack a situation never seen or studied before and for which data are often incomplete, with an acceptance of full responsibility for solving the problem presented on a professional basis.

Non-Departmental Engineering Courses—Such courses as electrical engineering for non-electricals, heat engines for non-mechanicals, etc. should emphasize fundamental ideas and principles and methods, rather than special machines or devices. The most important engineering background of the professional engineer, apart from his major field, lies in the basic sciences and the engineering sciences.

The study of engineering materials, including laboratory testing, is often scattered through several courses and can be coordinated to advantage. Increasingly, forward-looking engineers are searching the recent advances in solid-state theory and chemistry for an entirely new and fundamental scientific approach to their study of the behavior of materials. This field appears to be almost ready for engineering conquest. This development will bear very close watching by engineering educators.

Shop courses and some laboratory courses that emphasize practical work and that tend to displace engineering science in the curriculum should be scrutinized critically in the light of the instructional goals already discussed.

The art of measurement, including analysis of accuracy, precision and errors, and the appreciation of the degree of accuracy economically justified, together with some understanding of statistical methods, are areas worthy of attention in connection with various laboratory courses. The laboratory also has unique value as a place where the applicability of theories may be checked.

Graphical expression is both a form of communication and a means for analysis and synthesis. The extent to which it is successful, for these purposes, is a measure of its professional usefulness. Its value as a skill alone does not justify its inclusion in a curriculum. The emphasis should be on spatial visualization, experience in creative thinking, the ability to convey ideas, especially by free-hand sketching, which is the normal mode of expression in the initial stages of creative work.

Humanistic-Social Studies—The importance of substantial competence in humanistic-social areas should be apparent from the earlier consideration of instructional goals. The educated person has interest and elementary competence in several areas distributed over the broad fields of the humanities, the social sciences and the natural sciences. He has acquaintance with the subject matter of these fields, with the influence that they have on the lives of men, and with the characteristics of thinking that are appropriate to each field, ranging from the highly precise quality of thought in the natural sciences, to the

more tenuous and intangible concepts in art or philosophy. He has developed standards of judgment by which he distinguishes, in each area, that which is good from that which is mediocre. He will, if his total educational experience has been fortunate, have been exposed sufficiently to high quality influences so that those things of lesser quality fail to attract him.

One who has been fortunate to achieve such a sense of values has attained a preparation for living to which all should aspire. Engineers increasingly recognize that technical competence, alone, is insufficient. Understanding beyond technical knowledge is necessary for engineers who take a place of equality or leadership among the community of educated men.

Traditionally, breadth of education has been attempted by exposure of engineering students to courses in social studies and humanities. Such courses are not enough. The atmosphere in an engineering college, although intangible, is of first order of importance. It must be favorable to a liberal education for student success in this direction. One engineering instructor who disparages human values can seriously damage the value of humanistic-social courses in the eyes of those students who look to him as their ideal. Unless, and until engineering faculties appreciate and understand their colleagues in liberal arts, the value of such courses for engineering students will be small. The purpose of such courses is not only to supply tools for solving specific engineering problems, but also to develop a wise citizen and a broadly educated man capable of intellectual appreciation and enjoyment.

The value of personal association of the engineering student with other students and with professors in liberal arts, cannot be overlooked. The exchange of ideas and opinions in open discussion is a source of stimulation toward the acquirement of greater knowledge.

The seeking for immediate usefulness in the social studies and humanities, as tool subjects in engineering, may well lead to failure to achieve the objectives set forth above. Such courses as accounting, industrial psychology, investment economics, comparative costs, or city management may be just as technical as engineering studies. It is outside of such fields that the social-humanistic studies must lead the student. The Committee recommended a much broader study of the effectiveness of the social-humanistic stem of engineering education. Such a study is now under way under ASEE sponsorship.

One aspect of English merits specific comment. Instead of sole dependence upon specified courses, a level of performance should be required in written and oral communication of all engineering students which will develop in them the ability to convey their ideas to others in a clear, logical and interesting manner, using correct and concise language. The attainment of this objective is the joint responsibility of all teachers.

Making Room for New Curricular Material

In this report, several additions to curricula have been recommended without corresponding deletions. More emphasis on fundamental science, more on engineering science, and more on the broad humanistic-social area have been recommended than are contained in most engineering curricula. This does not imply that the engineering student needs to be worked harder. Indeed there is considerable doubt as to whether there is any margin of student time left. Four possibilities for achieving these additional, important objectives are listed below. Each school, no doubt, will wish to choose its own methods, recognizing that those suggested are of varying degrees of practicability to each institution.

These four are as follows:

(1) Raise the prerequisites for entrance. This might entail
   a. More adequate high school preparation.
   b. Higher selectivity.

(2) Increase the efficiency of instruction.
(3) Eliminate some of the material now in the curriculum.
(4) Extend the curriculum to more than four years.

Much has been written about high school preparation. Continuing encouragement should be given to high schools to raise their standards, and to give appropriate training to college-bound students, including engineering students. However, it is doubtful whether engineering educators can realistically entertain serious hopes for substantial gains from this source over any short period of time. One ray of hope lies in the summer programs for high school science teachers that engineering schools, with the cooperation of industry, have been offering.

Although higher selectivity would permit a more rapid rate of academic progress, it would decrease the number of applicants at the very time when national welfare calls for the reduction in the present shortage of engineers.

Increasing the efficiency of instruction is a process more or less continuously under study by many faculties. Newer, simpler ways of looking at complicated phenomena and their analysis evolve continually in the minds of an alert faculty. Profound understanding is often accompanied by the ability to give the simplest and clearest statement. One contribution of our graduate schools to undergraduate education should be a continuous improvement in methods of presentation in undergraduate programs due to better understanding and consequent simplification of subject matter. Such development of better understanding and consequent simplification can, undoubtedly, contribute in an important manner to the solution of the present problem.

Elimination of material now in the curriculum, likewise, is an accepted practice in rapidly growing fields. Two kinds of material can well be looked at with a view toward possible elimination. The first is unduly repetitious material. Conscious repetition, carefully designed as a pedagogical instrument, is necessary, but it detracts seriously from student interest. Much unplanned repetition exists. Other areas due for close scrutiny, with a view toward possible elimination or reduction in time, are those courses having a high vocational or skill content, and those primarily attempting to convey engineering art or practice. The latter belongs in many engineering courses, but its high purpose is to illuminate the engineering science, analysis or design, rather than to teach the art as engineering methodology.

A review of the evolution of engineering curricula over many years shows a trend toward increasing emphasis on the science underlying engineering at the expense of the study of engineering art for its own usefulness. This trend would appear sound for application in the present dilemma.

Thus, the Committee feels that the most promising possibilities of finding time for increased emphasis on fundamental science, engineering science and humanistic-social studies are (1) elimination of some of the present curricular material, and (2) increased efficiency of instruction. Experience would indicate clearly that the faculty that really wants to achieve such ends can and will find a way.

The Committee, after careful consideration, takes no position with regard to the length of the program. It believes, however, that further experimentation is in order in all four of the means suggested for introducing new curricular material.

Providing Opportunities for Gifted Students

Leading engineering educators have long felt that the standardization of engineering curricula in the United States has provided too little opportunity for outstanding students with creative talents to develop these capacities at their greatest possible rate. Most courses are organized

to proceed at a rate that can be followed by the average, and, commonly, by the below-average student. At some place in the undergraduate program there should be an opportunity to break down this lock-step and permit the student full play of his intellectual and creative powers.

The Committee is aware of three possible methods for providing such opportunities. The first is the special curriculum, designed both in content and in method of administration to challenge adequately the exceptional group at the top of a class. The second method is that of permitting the exceptionally able student to elect his program widely, with due precautions against excessive specialization, to carry as heavy an academic load as experience indicates he can handle; and, in general, to let him build out of the courses that may be available a program that is stimulating and challenging to him.

The third method, and the one that philosophically has the greatest appeal, is that of giving the student a great degree of personal freedom to study individually under general supervision and guidance, in whatever way appeals to him as being most effective in his individual case. Combined with this, of course, must be a rather infrequent, but very searching examination, designed to provide an overall test of his accomplishment and to test his level of understanding in a broader and yet more penetrating way than the usual term examination.

The first and second methods, that is, the special curriculum for a gifted group and the individually-elected curriculum, respectively, are in regular practice at various institutions in the country. Any adviser, when given freedom to adjust the curriculum, can adopt the second method when he recognizes among his students one who is capable of benefiting from such a program. While the results of such procedures are extremely difficult to measure with any degree of certainty, the evidence is not unfavorable.

With the third type of program, on the other hand, experience in engineering in this country has not been conspicuously convincing. One difficulty is that, given a large measure of freedom as to place, method and program of study, with only the most general sort of restraints in the form of general examinations at the end of one or two year periods, very few students will absent themselves from rather regular classroom exercises, if these are handled in a reasonably interesting and inspiring manner. They find that the class exercises of such a professor are an exceedingly effective way of acquiring basic, scientific disciplines. Other students, who take seriously the admonition to study independently, often have found the imposition of sufficient self-discipline to assure the same intensity of intellectual effort and actual accomplishment as that achieved by the regular students to be more than they could muster. This has been revealed disconcertingly, on occasion, when such a student has later been faced with the searching doctoral examination in which demonstration of relatively elementary ideas, but at a profound level, has been required. The student who has enjoyed complete freedom under general guidance, somehow has often failed to acquire the degree of exacting mastery of basic principles that is expected.

On the other hand, the brilliant student who becomes the personal protégé of a wise and able professor may attain extraordinary achievement under a free program. This rather rare student is obviously an exception to all rules, and the perceptive and wise faculty member will break all rules in order to allow him to develop his own initiative and ideas. Such students will set their own courses, the faculty member notwithstanding, and they do not constitute the problem being considered here. The adequate social development of such individuals, however, may be a serious problem.

It is, therefore, the rather select group found in the top ten per cent of a good class, but excluding the near genius who is a law unto himself, with whom faculties should be more concerned. There are, of

course, many ways in which the monotony and tedium of the highly organized classroom course for these students can be relieved. All the individual encouragement should be given them which will help stimulate them to something beyond the usual performance. There is a great need for continued experimentation in this area in the search for the solution that apparently is still to be found in this country for this important problem. The European solution, although excellent in its natural setting, has not proved susceptible to direct transplantation to this country. The strongest encouragement should be given to those teachers and administrators who would like to experiment in increasing the responsibility of gifted students for their own education.

Student Selection and Advanced Standing

It is recommended that high school students interested in engineering be encouraged to prepare themselves adequately for engineering work in high school by developing proficiency in the use of English and mathematics, and in gaining an understanding of science, particularly physics and chemistry. A most effective way of so encouraging these students is to make proper adjustment in the work required of them in engineering schools. This may be done by allowing college credit for previous work, or if this is undesirable, by making the credit hours required for graduation flexible and dependent upon the preparation and skills of the entering student. A student should not be required to repeat work in college if he is adequately prepared by work already covered, or by proficiency previously acquired in high school or elsewhere, but instead he should be allowed to proceed into more advanced work. When so excused from taking a specific course on the basis of previously developed proficiency, the student should not be required to substitute other work not demanded of the other students, for this requirement always discourages the student from presenting advanced work for entrance. However, proficiency should be determined by examination and not assumed because of the acquisition of high school units beyond those required normally for admission.

Requirements for admission to an accredited engineering curriculum must of necessity be rather rigorous to insure adequate capability of the student to pursue engineering in an orderly and effective manner. The Committee, therefore, recommends the following minimum requirements for admission:

1. Graduation from an accredited secondary school, or its equivalent in education.
2. Demonstrated capacity for satisfactory achievement in engineering.

It should be recognized that the minimum requirements listed above impose great responsibility upon directors of admission for proper selection of students to engineering colleges, especially when the availability of required courses in the various high schools is taken into consideration. Such students should normally accumulate at least 3 units each of English and mathematics and at least 1 unit of science if they are to make satisfactory progress in engineering schools. Furthermore, unless suitable screening techniques are applied, such students should stand in the upper quarter of the overall integrated group of high school graduates. It is suggested that pursuit of vocational courses should be discouraged as preparation for engineering and that not more than 2 of the 16 units for entrance should be considered from drawing, shop or other vocational work. Additional background in mathematics, science and humanistic-social courses is of far greater benefit to the student.

The Committee also recommends that colleges should:

1. State their requirements for admission clearly.
2. Elect to admit students with deficiencies only when there is strong evidence to indicate probable success in engineering

and always state clearly what these deficiencies are and how they may be removed.

3. Maintain records of criteria used to determine admission.

4. Use such records to improve the screening process.

Students transferring from accredited junior, liberal arts or other engineering colleges should be admitted on a provisional basis, and the final transfer of their credits should be delayed until their subsequent records indicate maintenance of the required grade point average for graduation. A realistic evaluation of credits presented for advanced standing should be made on the basis of course content or proficiency examination rather than on an inflexible basis of equivalent credit hours.

High School—College Articulation

As preparation for engineering education, there is no substitute for scholarly levels of instruction in high school, with adequate emphasis upon developing both interest and reasonable proficiency in mathematics, English, physics and chemistry. The Committee on Evaluation believes that a great deal can be done to improve the scholarly quality of education offered in the high schools. This can best be accomplished by developing close working relationships between engineering colleges and high schools at the local level. Some engineering colleges have developed conferences and educational programs, participated in jointly by high school and college teachers. Several industries have provided financial support for educational programs. These programs can be highly effective in giving high school teachers insight into the nature of science and mathematical preparation which is needed by students who plan to take science or engineering in college.

In order to encourage high school-college articulation, it is recommended that a study be undertaken by ASEE in cooperation with industrial groups and societies representing mathematics and the pure sciences to:

1. Develop specific techniques for identifying, encouraging and developing those high school students who have aptitudes for engineering or science.

2. Develop specific techniques of reaching high school faculties and administrators in order to enlist their cooperation in a constructive program to improve the quality of high school preparation, particularly in mathematics, physics, chemistry and English.

3. Determine, at each university having a college of engineering, how to provide advanced study as a part of high school teacher education that would make such teachers more proficient instructors of the subjects necessary for admission to engineering.

4. Develop specific techniques for presenting these problems and their possible solutions to high school administrators, teachers and the general public.

Graduate Work and Its Relation to Undergraduate Curricula

So far, this report has been devoted essentially to undergraduate engineering curricula. Graduate work has such important implications for engineering and its objectives are so related to undergraduate curricula that this subject must not be neglected in this report. However, a much more extensive evaluation of graduate study is being planned by ASEE. An undergraduate curriculum must serve a two-fold purpose of preparing some men for immediate employment and others for graduate study. This Committee believes that a single curriculum with a reasonable degree of flexibility, as represented by electives, can meet both of these objectives.

In recent years there have been marked increases in the number of graduate students in engineering and in the number of institutions offering graduate study. The rate of technological advance suggests that an even larger fraction of engineering graduates must go on to graduate study in the future. This imposes upon engineering teachers the obligation to

identify and encourage those students who are properly qualified to pursue graduate work. Many small schools have impressive records in preparing and encouraging their students for graduate work.

Schools which lack adequate research facilities or a faculty with sufficient academic preparation to carry on graduate study can still serve a very important function in advancing graduate level education by providing scholarly undergraduate preparation and by encouraging their better students to continue their education after graduation. Graduate students usually benefit by the diversity of faculty contact which they receive when they change schools at the end of their bachelor's degree.

Graduate students may also benefit from some knowledge of practice. However, the temptations to continue in employment have been so great that the advice to seek employment ahead of graduate study has not produced the result intended. The current sponsored research programs of engineering colleges are such as to provide an alternative to the need, that was so widely felt in the past, for graduate students to bring a knowledge of practice into their graduate work.

The current increase in emphasis on graduate work has raised many questions to which engineering schools are seeking an answer. It appears desirable for this Society to undertake a comprehensive study of graduate work in a way quite parallel to that in which the Committee on Evaluation has studied undergraduate engineering curricula. The following questions and problems are suggested for possible study by such a graduate evaluation committee.

1. When, or under what conditions should an engineering school undertake graduate work? Matters of financial support, subsidy available for graduate students, sources of money for research, support for an expanded faculty and even housing for graduate students arise.

2. All graduate work which is more than an additional year of undergraduate study involves substantial additional investment either in faculties or facilities or both. Therefore, it should not be undertaken without appraising the cost.

3. Should graduate work be specialized or fundamental? One sometimes hears that undergraduate study is fundamental while graduate study is specialized. Those most experienced in graduate work in engineering are likely to feel that graduate work is rather a medium both for deepening and broadening the scientific base for engineering. Sometimes subject matter that appears to be rather specialized provides the most effective stimulus for more fundamental study.

4. What are the requirements for a graduate faculty or a faculty competent to offer a high grade graduate program? In many institutions members of a university faculty are authorized by special election or designation to participate in graduate work. The scholarly standards to be met by thoroughly competent graduate teachers are frequently of a different order from those meeting minimum requirements for undergraduate teaching. Salaries that are barely sufficient for holding an undergraduate faculty may be insufficient to attract and hold competent graduate faculty. The important criteria for a graduate faculty as distinguished from an acceptable undergraduate faculty must, therefore, be specified.

5. The demand of industry for engineers with more than baccalaureate education has resulted in extensive part-time programs at the graduate level for industrial employees. Do such programs meet high graduate standards? Under what conditions do they meet such standards? What are the safeguards that must be applied to assure high academic standards? Is part-time study alone sufficient or of such character as to provide degree programs comparable with those involving full time residence study?

6. What are the requirements for degrees? Should the Master's degree require a thesis? What should be the language requirements, if any? What should

be the residence requirement, if any? To what extent would the degree be essentially a certification of ability of the candidate and to what extent a certificate of satisfactory participation in the institution's own intellectual life and activity?

7. At the doctoral level, what are the examination standards? What characterizes a good examination? What should such an examination seek to demonstrate? Who should be examiners? What emphasis should be given to written and oral portions of the examinations? What are good examination techniques?

8. What constitutes a good doctor's thesis? What are the criteria for judging such a thesis? How does one determine whether or not the criteria for measuring the contribution to knowledge have been satisfied? What should be the course requirements for a doctorate, if any?

All of the questions pertaining to doctoral study, and many others can be answered only in terms of many intangible elements that, taken together, represent a high level of scholarship, scientific and engineering perception, and standard of intellectual attainment. As a concluding remark, it may again be emphasized that undertaking graduate work, of which an institution can be proud, involves a substantial reorientation of objectives in an engineering department and additions to faculty and facilities that may represent major elements of cost.

Since this Interim Report deals so briefly with graduate study it is recommended that those interested in this phase of engineering education refer to A Manual of Graduate Study in Engineering, published in 1945 as an ASEE Committee Report (*Journ. Engr. Educa.*, Vol. 35, p. 650) and revised and reissued in 1952 in monograph form.

Evolution of a Common Stem of Engineering Curricula

The great changes that have come about in physics and chemistry over the past thirty years and the equally great advances in engineering practice seem not to have produced an equivalent counterpart in a reorganization of engineering curricula. At a meeting of the Committee on Evaluation of Engineering Education a group of industrial advisors pointed out that the problems in production and manufacturing are now demanding greater and greater scientific background for engineers. As one example, emphasis was placed upon automation of machines as a current problem of the machine designer. The need for such instruction is critical in certain industries, and several of these offer such courses to their personnel. If this is generally true, engineering education may be a decade late in giving emphasis to electronics in the curriculum of mechanical engineering and in teaching applied electronics as a part of machine design.

Unchanging Factors in Curriculum Design

It is relatively easy to look backward and recognize changes, but it is always more difficult to visualize what lies ahead. After facing many questions regarding the future of engineering practice one is likely to conclude that the teaching of practice, as it exists today, will always be of limited use because the graduate is certain to find practice changing year by year. And, as a matter of fact, the engineering art taught in colleges will normally reflect practice that is already, in part, obsolete since the teacher's knowledge of practice becomes rapidly outdated.

But fortunately, some things do not change. Reactions, stresses and deflections will still occur, and they will have to be calculated. Electrical currents and fields will follow unchanging laws. Energy transformation, thermodynamics and heat flow will be as important to the next generation of engineers as to the present one. Solids, fluids and gases will continue to be handled, and their dynamics will have to be understood. The special properties of materials as dependent upon their internal structure will be even more

important to engineers a generation hence. These studies encompass the solid unshifting foundation of engineering science, upon which the engineering curriculum can be built with assurance and conviction.

Attitudes of Engineering Faculties

The Committee on Evaluation of Engineering Education had arrived at this conviction soon after its organization. The problem that then faced the Committee was to think through the implications of the steadily increasing importance of the engineering sciences upon curriculum design and upon faculty, students and employer relations. The questions to be answered were of the following nature. Would faculties believe that much stronger emphasis upon the engineering sciences and the basic sciences produce only research men? Would the employer be pleased with the product or would he feel that students should be able to earn their pay immediately upon graduation without special job training? Could students undertake a more scientific program without excessive failures?

Not knowing the answers to these questions the Committee suggested in its Preliminary Report the concept of bifurcation as a possible means of transition from the present curricula, which are largely of the general-professional category, to the strong professional-scientific curricula that it visualized as being required for an unknown, but in no sense negligible, percentage of future graduates. As defined in the Preliminary Report, the professional-scientific curriculum included increased emphasis upon mathematics and physical science, the nine engineering sciences as previously described, and a sequence of courses in engineering analysis, design, or the study of engineering systems extending over two years.

After the discussion of the Preliminary Report by the Colleges of Engineering a reasonably clear viewpoint was forwarded to the Committee. This viewpoint consisted of three parts: (1) A strong support for higher standards of accreditation for engineering education but not for designation of especially meritorious curricula. (2) A nearly universal institutional reaction that engineering curricula should not be subdivided into two functional stems but a recognition of the usefulness of functional variation at the top. (3) A growing desire for curricula to approach the definition given in the Preliminary Report for professional-scientific curricula which the country seems to accept as being the probable direction for the evolution of engineering education.

Viewpoint of Employers

After receiving this expression of attitudes from the engineering institutions, the Committee determined to learn something of the viewpoint of employers. At a meeting in Atlanta, Georgia, in February, 1954, seven of the largest employers of engineers were invited to advise the Committee on Evaluation. These organizations employ all types of engineers in all functions from research to sales and construction. In fact, most of the organizations represented employ only a small fraction of their engineers in research, development and design. On the average, less than 25 percent of their engineers work in these fields. One company has most of its engineers employed in operation, another in manufacturing and a third has one of the largest construction organizations in the country. Several employ nearly one-half of their engineers in sales. Nevertheless, the industrial representatives present concluded that they would prefer nearly all of their engineers to be trained in professional-scientific curricula as defined above. The industrialists emphasized that their sales, manufacturing and operation or maintenance engineers needed strong scientific backgrounds just as much as the research and development engineers and designers.

They were unwilling to sacrifice courses in engineering science to provide time for the study of technology or administration at the pre-baccalaureate level since they

believe that these can be obtained under company sponsorship whenever needed.

It seems necessary to discuss the obvious criticism that the industrial advisors to the Committee on Evaluation represent only large employers. The criticism is valid, but there seems to be no way to obtain an equivalently valid opinion from small employers. However, there is reason to believe that small employers even more than big industry need versatile engineers since one man in a small company often designs and builds the product and plans its market in competition with big industry.

Abilities of Engineering Students

The Committee on Evaluation has also given consideration to the question of whether a stronger emphasis upon basic science and engineering science would lead to increased failures to complete engineering curricula. Some who have experimented in this direction give assurance that this common assumption is not necessarily true. The best authority to the effect that engineers can handle additional work in basic science and engineering science without undue difficulty lies in the results of national tests. These indicate that, both at the undergraduate and graduate levels, engineering students show the same high level of mental ability as students of the physical sciences. It seems reasonable to conclude, therefore, that the principal groups of engineering students will prove able and interested in completing whatever type of curriculum the profession of engineering considers necessary preparation for its prospective members.

Opportunity for a Common Stem in Scientifically Oriented Curricula

The consideration of curricula cannot proceed wholly on a philosophical or qualitative basis but must eventually be approached quantitatively in semester hours. The Committee on Evaluation, in order to clarify for itself the practicability of its suggestion that curricula of the 4-year type can be designed with an enhanced scientific orientation, has developed for consideration the broad outline of a professional-scientific curriculum. *It intends this skeleton curriculum to be considered as suggestive rather than restrictive. The great need of engineering education at this time is for experimentation with, rather than standardization of, curricula.*

In defining an engineering curriculum the Committee on Evaluation has first indicated the need for mathematics through differential equations; however, another application of calculus such as statistics might fit more effectively into industrial or sanitary engineering. Nevertheless, for many curricula this means at least one additional course in mathematics. The recommendation that physics should be extended through nuclear and solid-state physics may well require more than the usual eight semester hours of sophomore physics even though there may be some saving by elimination of unnecessary duplication with mechanics, thermodynamics and electrical engineering courses. There is a growing belief that a speaking acquaintance with organic chemistry and a working knowledge of physical chemistry is essential to all engineers and that this objective cannot be accomplished within the usual course in freshman chemistry. For most curricula these changes in mathematics, physics and chemistry would probably require a total of at least 6 semester hours of additional study.

The second major factor in the original definition of scientifically oriented engineering curricula included nine engineering sciences in sufficient strength to justify their separate listing; i.e., (1) statics, (2) dynamics, (3) strength of materials, (4) fluid flow, (5) heat flow, (6) thermodynamics, (7) electrical currents, fields and electronics, (8) engineering materials, (9) physical metallurgy. So that some quantitative measure may be available, it is tentatively suggested that each engineering science deserves from 2 to 6 semester hours, the average being about 4 semester hours. Hence, there would need to be a

total of 36 semester hours for the engineering sciences mentioned, including appropriate substitutions of other applied sciences in special curricula.

The third major element in the definition of an engineering curriculum is that it must contain an integrated sequential study. By this is meant that the mathematics and the basic science shall be used proficiently in the courses in engineering science, and that the latter, in turn, shall be used proficiently in engineering analysis, in the study of engineering systems, and in preparation for creative design work. For the scientifically oriented approach it seems desirable that analysis, synthesis and creative design cover four successive semesters at an intensity to be represented by 5 or 6 semester hours per semester.

In addition, to basic science and engineering science, allowance may be made for a minimum three-credit-hour humanistic or social science course each semester for at least seven semesters and also for a small amount of required technology. On this basis the common stem of any scientifically oriented curriculum may be described as follows in four blocks totalling about one hundred semester hours.

The Committee has used the term "common stem" in an attempt to clarify the necessity for a unity of understanding by students in different curricula. There is no reason why such unified understanding can not be achieved by somewhat different paths, through different courses, with different instructors. It will not be achieved, however, if technology is substituted for basic and engineering science or if courses with names from the fields of engineering science are presented merely as a necessary sideline to the objective of teaching current practice.

The Committee's interest in the curricula outlined above is centered in: (1) the indication that the concept of 4-year professional-scientific curricula is practical, (2) the indication that considerably more than the usual "common freshman year" is a normal evolutionary result that may accompany scientific orientation of curricula, (3) the opportunity presented by an "equivalent semester" of elective study for meeting the interest orientation of students and the functional needs of the engineers engaged in research and management as well as in design and construction.

EXPERIMENTAL TIME DISTRIBUTION IN SCIENTIFICALLY ORIENTED ENGINEERING CURRICULA

(1) Humanistic-Social	21 semester hours
(2) Math and Basic Science (about equal in weight)	36 semester hours
(3) Engineering Science	36 semester hours
(4) Required Technology	7 semester hours
TOTAL FOR THE COMMON STEM	100 semester hours
(5) Major Departmental Sequence of Engineering Analysis, Design and Engineering Systems	21 semester hours
(6) Options or Electives in (a) Humanistic-Social, (b) Management, (c) Basic Science, (d) Engineering Science, (e) Research or Thesis, (f) Engineering Analysis and Design, (g) Technology	17 semester hours
TOTAL FOR THE 4-YEAR CURRICULUM	138 semester hours

These numerical figures in semester hours are to be taken only as rough suggestions since there will be many reasons for variations between institutions and among departments of a single institution. *Experimentation is strongly encouraged.*

Curriculum Adjustment to the Individual

The Committee on Evaluation recognizes as do most faculty members that there is need for as much flexibility as possible within the framework of a given curriculum for each student to extend his

own interests. Some choice may exist in the sequence of social-humanistic courses, in the later courses in mathematics and science, and in the departmental sequence of work in engineering analysis and design. However, it is primarily in the elective courses that the student can best extend his interest toward his future professional activity. The objectives of engineering education are best satisfied when each student is given a free choice of options or elective courses, provided that the courses elected contribute to a planned objective.

The question has been raised as to whether additional work in engineering science could be taught by present faculties without special advanced training. This indicates some confusion as to the objective being sought. Actually there can be no really advanced subject matter taught to undergraduate engineers. Therefore, there can be no question as to the potential competency of most members of present faculties to handle courses in the engineering sciences and in engineering analysis, design and engineering systems. It is merely a changed viewpoint that is desirable. Any teacher who recognizes that he can render very limited service to students by emphasizing engineering art or practice will shift his emphasis to a more scientific approach to engineering.

Conclusion

This Interim Report has dealt with the evaluation of engineering education and with the characteristics which differentiate engineering curricula from those in science. In determining desirable levels of mathematics, basic science and engineering science for engineering curricula, the Committee on Evaluation has been concerned with reasonable, obtainable objectives rather than with minimum standards for accreditation. The latter is the province of E. C. P. D. The present report is offered, therefore, as indicative of the direction in which engineering education should evolve.

The Committee sees no barrier other than tradition that would prevent the development of a common stem of the curricula in a given institution that might approach 100 semester hours. It does not, however, take the position that such unity is universally desirable, but points instead to blocks (2) and (3) of the illustrative curriculum which indicate that somewhat more than one-half of the total credit hours might appropriately be used in the basic sciences and engineering sciences with later emphasis upon the proficient use of these subjects in engineering analysis, synthesis and preparation for creative design as the capstone of engineering education.

The Committee further believes that the differences in the interests and the orientation of students and in the functional purposes of engineering education will be served best by elective blocks of courses equivalent in total to about one semester of study. The choice of such electives, however, should be made only in relation to a planned objective. Such elective study can contribute to the development of a stronger humanistic-social background for some engineers and to a stronger scientific background for others, with resultant overall strengthening of the profession of engineering.

Appendix A

Historical Background of Previous Evaluation Studies

Since the organization of the Society in 1893 there have been many studies of engineering curricula which reviewed content of the several programs and gave a distribution of time to the major divisions of the work. Out of the study begun as the Mann Report, published as Carnegie Bulletin No. 11, came the Wickenden Report of 1923–29, the monumental effort of the Society. It was followed by "Aims and Scope of Engineering Curricula" in 1940 and "Engineering Education After the War" in 1944. Dr. D. C. Jackson's "Present Status and Trends of Engineer-

ing Education in the United States" was published in 1939, and its study of curricula may be considered as a supplement to the Wickenden Report.

Since the Wickenden report is so basic and fundamental it may be desirable to quote a few sentences:

"The multiplication of trunk and branch curricula based on technical specialization has gone fully as far as can be justified. Further differentiation in courses for undergraduates is much more likely to proceed on functional lines."

Some colleges did not heed the suggestion that multiplication of curricula had gone far enough, but have continued trunk and branch divisions throughout the last 25 years.

The Wickenden Report also emphasizes the necessity for continuing study after graduation:

"The most serious deficiency in engineering education is not so much in matter taught or matter omitted in college as in allowing the orderly process of education to stop, where it so often does, at graduation."

It is difficult to over-emphasize the necessity of learning how to study and of continuing study throughout a whole professional career.

The 1940 and 1944 reports, referred to above, emphasized the division of each curriculum into two major areas, titled the scientific-technological stem and the humanistic-social stem. These two studies renewed interest in the "general academic subjects" listed by Wickenden. The wording describing the humanistic-social stem used is practically identical in both reports and the time suggested for this area was twenty per cent of the total. The program was to be an integrated sequence running through four years. During the last decade much thought and much study have been given to this phase of engineering education.

Both reports recommend the 4-year undergraduate program as the desirable norm. However, it was recognized that engineering graduates enter into many kinds of activity and that there should be comparable differentiation in the educational programs. In summarizing the 1944 report, Dean H. P. Hammond outlined the needed preparation for widely varying engineering activities as follows:

"In order to provide for the satisfaction of the needs incident to these trends, the (1944) Committee suggests, for consideration, a plan of curricula differentiation in the fourth year, through which three options would be offered within each major professional curriculum: (1) Continuation of the present type of 4-year program essentially as a terminal curriculum, but with modifications advocated by the Committee, for a majority of students. (2) An alternative fourth year emphasizing subjects dealing with the management of construction and production enterprises. (3) A fourth year intended to prepare for additional years of advanced study by strengthening the student's command and extending his knowledge of basic sciences and mathematics, and by introducing him to the methods of advanced study. This fourth year, and the year or years of graduate study to follow, would be planned as a unit rather than as two stages marked by the usual differences of undergraduate and postgraduate programs."

In 1952 the Society conducted a comprehensive study on methods of improving engineering instruction. This report dealt at considerable length with the problem of "how to prepare students to meet new situations with skill, resourcefulness and leadership."

It also treated the collateral problems of "how to instill in the student the desire to continue to learn after graduation, and how to provide a cultural foundation which will encourage him to contribute to his local community and to civic groups as a mature, thinking, human individual.

The principles of learning stressed "the importance of effective participation on the part of the learner; his motivation through the formulation of a goal; the clear definition of task assignments (preferably defined by the student himself); the evaluation of his progress; and his repeated practice in application." This

project was participated in by committees in over 100 engineering colleges of the country.

In 1945 the Graduate Studies Division of the Society prepared a Manual of Graduate Study. This was completely rewritten by a Committee of the Division in 1952. This Manual deals with:

(1) the objectives of graduate study, (2) organization, (3) transitional studies, (4) developing a graduate faculty, (5) admission requirements, (6) degree requirements, (7) major, minor, and research, (8) the thesis, (9) language requirements, (10) mathematics, (11) examinations, (12) undergraduate courses, (13) non-technical studies, (14) evening classes, (15) cooperative programs, (16) sponsored research, (17) industry institutes, (18) foreign students, (19) student guidance, (20) graduate study in engineering.

Appendix B

Letter to a College President by Harold Hazen, Chairman Region 2, ECPD, Education Committee. Reprinted from *Electrical Engineering* . . .

April 2, 1954

"The important quality that we look for in a faculty is evidence of professional stature and competence, including the kind of competence that may take any number of forms or combination of these. In the case of a fellow in his thirties, or even forties, we are interested to see if he has a doctorate, since if he has, it is evidence that he has had sufficient scholarly interest to go on for graduate work and research. But the doctorate of itself is neither necessary nor sufficient evidence of the quality for which we are looking. It is not necessary because there are many young men of first rate ability who have elected not to take graduate work. We usually ask how it is that a man who is interested in education has not taken the rather natural route of graduate work and the resulting advanced degrees, but we are quite willing to be convinced that there are reasons not affecting his qualifications. On the other hand, the man may have the qualifications to earn and actually hold an advanced degree and still not have the personal qualities or indeed the effectiveness in professional work that would qualify him well as a faculty member. Thus while we use the doctoral degree as a quick, rough-and-ready indicator, it is an indicator rather than a measure of the qualities for which we are looking.

"In an older man, whose formal education took place at a time when advanced degrees in engineering, especially at the doctoral level, were comparatively rare, we would have even less basis for insisting upon a doctoral degree. In such a case we nearly always have to look to other criteria as a basis for appraisal.

"In a faculty of several members in a given department we are likely to expect to find from one to several members holding doctor's degrees, if the faculty is really good. However, it is perfectly possible that professional qualifications of the sort I will mention in a moment are sufficient to demonstrate excellence.

"Publication is another indicator of professional stature. Here again, the mere fact that a man has published a number of papers does not in itself have significance. One asks: were the papers good, did they make significant contributions, were they well regarded by competent men in the field, are any of them recent publications? If the publications are in the form of books, we ask, is the book recognized as making a genuine professional contribution either to the field or to the teaching of the field? On the other hand, is it merely a compilation in a different form of material already available in book form to the profession?

"Another indicator is the kind, if any, of professional work upon which the man is currently engaged. Does he have any investigatory activity under way? One important form of such investigatory activity is research. Such research would usually, though not invariably, be carried out in the institution, either with institu-

tional funds or some form of sponsorship from industry or government. If such work is under way, is it basically just testing? Is it puttering in its professional standards, or is it work that really digs into some new area and offers some promise of real contribution to the profession? This work may be applied or of a fundamental character. If applied, it should still have real intellectual challenge, involve imaginative exploration of new ideas, and in general be of such nature that if it is well carried out, it should lead to publication welcomed by the accepted professional journals in the field. Such research is always stimulated and facilitated if the staff member attracts graduate students as co-workers in such a project. Graduate students, however, are not essential. Such a project need not be large. It may, in fact, be quite modest in its physical and fiscal dimensions. The important point is the quality of intellectual effort involved and the professional significance of the investigation.

"The development of specific hardware may or may not represent good research activity in engineering. The test is not whether or not the product is produced in pilot model or other form, but rather the kind of professional effort that is required and the level of professional competence that is demonstrated.

"Another possibly significant kind of professional work is consulting. We ask, is the man doing any consulting work? If he is, we again ask, is it of a routine character or does it involve substantial responsibility? Is it concerned with some new development, or is he merely doing some handbook-arithmetic application of well-known principles in a routine fashion?

"Another indicator, and a very important one, is the kind of teaching that a man is doing. Is he continually revising the subjects that he teaches in response to the impact of new developments? This does not mean, for example, asking in the field of electrical engineering whether he is teaching television or not; rather it means, is he taking into account in his selection of the areas in the fundamental engineering science that he treats, the kinds of principles that one must understand if he is to have a basic understanding of the field of television? A continuing evolution of the teaching of even so elementary and fundamental a subject as electric circuit theory or electric field theory is evidence of a scholarly and active mind that we like to see in a teacher. We are skeptical of the man whose course has not changed very appreciably in the last ten years in the orientation, outlook, and selection of subject matter. Again this most emphatically does not mean that we expect a professor to teach applications. It does mean that we expect his handling of fundamental courses to reflect, in the selection of material, the selection of illustrative problems, and in the associated laboratory work, the needs of the fields that are active today in practice.

"The kind and quality of a man's teaching technique and the effect this has on his students are significant. Here the evidence is often hard to get and necessarily rather intangible. Nevertheless, there are often indicators as to whether the man's class and laboratory teaching is of a character to stimulate the imagination of his students, to develop their initiative, to challenge their abilities, to broaden their outlook, to impose real responsibility on the student. The contrast with this is the teaching that conscientiously but without imagination, ingenuity or contribution of its own, follows the content of some standard textbook. The problems a professor gives to his students are often very revealing of a professor's professional outlook and the kind of influence that he is bringing to bear on his students. The home problem or laboratory exercise designed to pique the student's curiousity or to make him think out something different from what the textbook has shown, is a good indicator.

"The level of penetration of a professor's teaching provide meaningful indicators of his intellectual stature and the

quality of his influence. Here we ask the questions, does his work have a large qualitative content, or does he emphasize more strongly the analytic, the mathematical, the scientific aspects? Does he cover the theory somewhat apologetically and superficially merely to satisfy a conscience before getting to problem work and applications? Does he try to get his students to understand the basic mathematical theory at least at an elementary level? Does he make free use of the calculus, and in the appropriate fields, even elementary differential equations, or does he stick to arithmetic and algebra alone? If he uses calculus, does he really understand it himself and use it with a reasonable degree of rigor? We feel that engineering schools offer an almost unique opportunity for a student to get the underlying theory and science, and that this school time is to a considerable extent wasted if it is devoted to qualitative, descriptive material in lieu of underlying, fundamental theory.

"We, of course, recognize the importance of the mature individual of broad experience and notable wisdom who can convey to his students an important contribution to their character and to their entire outlook on their profession and life. We should not underrate such a person when we actually find him, but neither should we make the mistake of attributing these high qualities to the genial, personable good fellow who has long lost (if he ever had any) his vigor and his technical acuteness. We must insist upon really acute and penetrating intellectual attributes and general technical astuteness of a superior sort to make our professor eligible for the true elder statesman category.

"Leaving teaching and turning again to other areas of activity, another indicator is the degree of participation of the faculty member in his professional society activities. By participation I mean not only attendance but taking an active part in the meetings and activities. The fact of participation itself is not sufficient. One needs to know whether his participation relates to significant ideas and issues, or whether it is shallow and conventional. In what repute is the man held by his professional associates over the country? Is he known to them because of his professional contributions, or is his name unfamiliar?

"Industrial experience can, of course, be an important measure of professional qualification. We need, however, to look at the nature and character of this experience very closely to determine its relevance to engineering teaching. Thus we look primarily not at the number of years, or even the administrative responsibility that a man may have carried, although these are not entirely unpertinent, but rather at evidence of intellectual qualities and activity that we feel are important in a teacher of engineering. Has he been responsible for significant new developments? Is he the sort of person who can be articulate in relating his engineering works to the underlying engineering science clearly and logically? Has his work been such that he has kept his underlying science and engineering science alive and up to date? Is his exposition clear and logical? Many practical engineers who achieve fine results do so by a kind of intuitive sense which, no matter how successful for a practical engineer, falls flat as far as effectiveness in teaching engineering students is concerned.

"Looking now at the overall appraisal, one cannot expect to find a high score for very many of the people on all of the above indicators of professional stature and competence. A good man, however, will score rather well on more than one of the foregoing categories, including one or more outside of teaching. The better the man, the higher his score and the more categories in which he will have a high score. Furthermore, in a good and well-rounded departmental faculty all of these qualities are present though seldom in any single individual.

"One final word regarding the doctorate is perhaps not out of place, especially as the importance of this degree as a qualifi-

cation for faculty appears to be so widely misunderstood. Doctorates are fine in their place, and they have a place, a place of increasing importance in engineering education. But let's neither give them too much weight, nor ignore them completely. Rather let us try by all the measures we know to determine whether this fellow about whom we are talking is one to whom we really wish to expose our engineering students.

"Thus far we have emphasized primarily the qualities of the individual person at which one looks in attempting to appraise a faculty member. A fine faculty, however, consists of much more than a group of individuals and individualists, who would qualify well according to the foregoing criteria. The element of team play and team spirit is almost as important in an engineering faculty as it is on a college football team. Do the various faculty members work together harmoniously and cooperatively? We must not be misled by the dulcet sound of the words 'harmonious' and 'cooperative.' A very important test of these qualities is the ability of these individuals to differ with each other vigorously and earnestly in an intellectual sense, and indeed on problems of a more philosophic character, but to maintain in all this a degree of objectivity and personal goodwill that makes the friendly golf match or wilderness fishing trip together just as characteristic as strongly expressed differences of opinion and judgment. One looks for evidence of fairly achieved compromise in the common core of earlier courses, and expects the curriculum as a whole to have a unity and singleness of purpose that provides strength. At the same time one looks for the tolerance that permits fine ability and special competence to have its head in elective subjects.

"One also looks for evidence of good leadership, leadership that insists upon a sound, well-rounded, forward-looking pattern in the curriculum and program. Sometimes a fairly firm hand is indicated from a dean to assure that enthusiastic individualists take sufficient time and thought in joint and cooperative effort to assure that their program as a whole makes sense, that it points toward worthy and forward-looking objectives, and considers adequately and imaginatively the advancing fronts of the professional field. But through all the activity there should be evident a spirit of goodwill, of willingness for some personal sacrifice in the common good, and a sense of pulling together that nevertheless encourages expression of individual ability and energy."

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

COMMITTEE ON EVALUATION OF ENGINEERING EDUCATION

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Report of Committee on Promotion of Ethical Standards*

It is quite gratifying to state to the members of the American Society for Engineering Education that the affairs of the Committee on Promotion of Ethical Standards are in good condition. Indeed, the condition of the committee's affairs is almost too good, as will shortly appear.

A year ago, the committee set for itself certain objectives, with the approval of the officers and the General Council of the Society. One of the most important of these objectives was to urge upon both individual and institutional members of the Society to consider engineering ethics very seriously.

It appeared necessary to undertake this special objective. That the committee would do so was implied by its appointment in the first place. Engineers probably pay less attention to professional ethics than do physicians and lawyers. Occasionally, an older and prominent engineer raises the issue of ethics. But engineers have usually assumed that they are all ethical, and always have been, and that it is a waste of time to think or talk about the matter.

Engineers incline to take an interest in tangible things: Reinforced concrete, jet engines, electronic controls of broaching operations, that sort of thing. Abstractions are repulsive to most of them.

The committee had misgivings at first. If they were to talk to the members of the Society about ethics, would not most of them shrug their shoulders and go about their business?

The committee owes a profound apology to the Society.

The committee published a preliminary statement in the December, 1953, issue of the JOURNAL OF ENGINEERING EDUCATION. The statement was entitled "On Engineering Integrity." The Society's reaction to this statement was a complete and encouraging surprise. It was impossible to handle the letters which came in. Six hundred and seventy-one items of correspondence remain in the files of the committee chairman. These include only letters which may have value later on. All completed correspondence has been destroyed.

Letters Express Approval

The letters expressed approval of the committee's statement, at least in principle. None were critical. A number of members, and other engineers, offered valuable suggestions for projects appropriate to the committee's aims, and of methods for doing the committee's work.

As was remarked a moment ago, the affairs of the committee are in almost too good condition. Heavy correspondence kept the committee from making progress in other phases of its operations. For example, the committee made no progress in its effort to prevail upon officials of the Society's divisions, committees and sections, to introduce discussion of ethics into their programs for the current year. It was quite impossible both to do this, and to take care of mail.

However, ethics items did turn up in several programs, as a result of interest in the topic. The session on Co-operative Engineering Education this evening, includes an item on ethics, and the entire session of the Division on Relations with Industry tomorrow afternoon is devoted

* Presented at the Annual Meeting of ASEE, University of Illinois, June 14, 1954.

to the topic. Discussions of ethics were included, likewise, in the annual meetings this year of the North Midwest and the Illinois-Indiana Sections of the Society, and in the session of the Young Engineering Teachers at the annual meeting of the Michigan Section. There was some negotiation for a speaker on the subject of ethics for the annual meeting of one of the southern or southwestern sections. We hope that these negotiations were successfully concluded.

Members of the committee delivered addresses on engineering ethics before engineering gatherings not associated with this Society.

Depending on circumstances, and the approval of the officers and the General Council, the committee will continue to keep the question of ethics in the minds of engineering educators by whatever measures and devices appear to be most appropriate.

Furthermore, the committee will at least look in the direction of ways and means of actually introducing instruction in ethics into colleges of engineering. It remains to be seen whether such instruction should be formal or informal, either or both.

The committee wishes to express its deep gratitude to officers, Council, and many correspondents for active encouragement and support.

Respectfully submitted,

THE COMMITTEE ON PROMOTION OF ETHICS, ASEE

W. W. BURTON
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R. W. VAN HOUTEN
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W. M. RYAN
B. M. TAYLOR

College Notes

With establishment of its new Geophysics Laboratory, says Director Joshua L. Soske, the **Stanford School of Mineral Sciences** now is equipped to take a front-rank place among schools training students in geophysical techniques of exploration for oil and mineral deposits. Stanford's recently-completed Henry Salvatori Laboratory of Geophysics was a $60,000 gift of Salvatori and the Western Geophysical Company of Los Angeles, which he heads.

Dr. George H. Lee, professor of mechanics at **Rensselaer Polytechnic Institute** since 1951 and head of the department for a year, has been made Director of Research at the Institute, it is announced by President Livingston W. Houston.

The Place of the Socio-Humanistic Studies in Professional Graduate Instruction*

By W. L. EVERITT

Dean, College of Engineering, University of Illinois

On behalf of the engineers, I want to express my appreciation for the opportunity of this joint discussion with the Council on Graduate Work. We have and will have many problems in common, for the interest and enrollment in graduate engineering programs is increasing.

I note that the Graduate Council devoted much of its attention at the Houston meeting to the "Education of the Whole Man at the Graduate Level." Essentially I have the same subject this afternoon, and the justification for a certain repetition lies in the advantage of the two groups discussing our mutual problems.

Engineering is a profession interested in action and in creativeness. It involves the employment of men as well as materials, and its practitioners are truly happy only when they are directing that employment for the benefit of mankind. From these characteristics stem both certain difficulties that engineering educators meet, and also certain challenges and opportunities that form the staple of my talk today.

The engineering colleges have for some time been concerned with many of these difficulties and challenges. To be specific, engineering education has been in a ferment since the war and much attention has been given to the problems of preparing engineering students for social responsibility as well as for technical competence. The report in 1944 of the Hammond Committee of the American Society of Engineering Education on "Engineering Education after the War," with its recommendation that at least twenty per cent of an engineering curriculum should be devoted to work in the humanities and social sciences, was an important step. However, although there has been much experimentation with the undergraduate four-year curriculum under this formula, there is still dissatisfaction with the results. It might be well to outline some of the pressures which make the solution of our problem so difficult.

Simultaneously with the development of increased interest in the humanities and social studies, technology has itself been expanding in an almost explosive fashion. In spite of increased emphasis on fundamentals and the elimination of most information on the "how" of industry, the amount of technical material necessary in the undergraduate curriculum increases continually.

Increased Interest in Graduate Work

These opposing forces have caused a few schools (though only a few) to increase their programs for the Bachelor's degree to five years. More important for our purposes today, they have also caused an increased interest in graduate work for both the Master's and Doctor's degrees. The increased need for technical training of the type given for advanced degrees is one important reason why engineering is not likely to move in the direction of medical education and require several

* Presented before the Joint Session of the Graduate and Engineering Councils of the Land-Grant Association, Columbus, Ohio, November 11, 1953.

years of liberal arts before the start of the engineering program. There is a further contrast between medicine on the one hand and engineering and physical science on the other. The medical practitioner seems to require a certain amount of maturity to generate confidence in his patients, whereas often the most productive years of creative scientists and engineers are their early ones. Therefore, there is real danger of loss in national creativeness if the training of the engineer is unduly extended and his active career too long postponed. (Remember we may also have to take into account two or more years of military service.)

Currently, there is much discussion of generalization versus specialization in education many times, I fear, without proper definition of terms. What may appear to be specialization in subject matter may in fact introduce generalization in method of attack or problem solving, and develop the ability to coordinate material from many sources. Use of the case method is an example. Ideally, one should proceed from the general to the specific, but unfortunately the mind of man, and particularly of a young man, does not easily move in that direction. A mathematician friend of mine once recommended we should teach algebra in the first grade and arithmetic in high school, because this would give generalizations first and applications second. Just try this on your children and see how far you get. I did. It has been urged by many that the undergraduate curriculum is the place for generalization, and the graduate program the place for specialization. But, frankly, this does not appear practical in engineering, and so while engineering educators are trying to broaden the work for the baccalaureate degree, they should not overlook the advantages of introducing still wider outlooks in the graduate program.

Broadness of intellectual interest requires maturity. Young people tend to concentrate on the interests they consider important. I do not believe this is a special characteristic of the engineer, but perhaps we notice it most among this group because of the intensity of their interest in their profession as undergraduates. This intensity is an asset as well as a liability. We find the engineering underclassman willing to work hard on scientific subjects, and we take advantage of this. If he is not so willing to work we weed him out. But the more intense his interest in science, the harder it is to excite him in the other fields of man's endeavor, because he does not as yet see their relation to his own needs or future life. Conversely it is probably also hard to interest the adolescent musician in science or the budding social worker in art. Being a man interested in action, the engineer is apt to ask how a given effort will contribute ultimately to his own actions.

Fortunately, as the engineer matures, his interests expand. For example, he may first see the usefulness of public speaking or a knowledge of the law. Furthermore, the wider the interests of his most admired professors, the more rapidly this broadening interest will expand. Therefore, any program for development of social interest requires the active support and participation of the engineering professors. President Hancher of Iowa, in his brilliant address entitled "Liberal Education in Professional Curricula" † before the general session of the Land-Grant Association, emphasized that one of the most important ways of introducing a broader culture is by incorporating in our technical courses reference to the relation of the subject matter to man's progress in economic and social development.

Proper Motivation

Proper motivation is an essential in education, particularly when only a limited time can be given to a certain area. Courses, required or elective, which produce in a student the feeling, "Thank God that is finished, I have gotten over a hurdle, I hope I never meet it again,"

† Published in the JOURNAL OF ENGINEERING EDUCATION, March, 1954.

have indeed failed their purpose. Social-humanistic courses in the engineering curriculum are intended to be an introduction to a lifetime of interest—not an end in themselves. It is for this reason that engineering educators have agreed almost universally that, given a certain amount of time available, social-humanistic studies should be introduced into the curriculum as a sequence running parallel with the technical courses rather than as a group of basic studies to be completed before the engineering program is started.

But this recognition of the need for maturity to develop a true interest in a broader culture for the engineer has generally had little impact on our graduate programs. We should recognize that while penetration into the unknown requires technical concentration, these are also the years when cultural interests are ripe for expansion.

This is not a problem unique to engineering; we have it in common with other fields such as agriculture and commerce where professional material is given in the undergraduate program and further graduate training is necessary for the leaders.

I wish to urge, as several others have before me, that graduate schools should give more attention to the development of a social-humanistic stem for their technical students. It is believed that this requires positive steps and programs rather than mere permission to use such areas as minors. Furthermore, it is in our graduate schools that we are developing the engineering teachers of the future. If, as President Hancher proposes, the cultural development of the four-year student is primarily influenced by a cultured faculty, then there is a special need for greater broadness in the education of our graduate students.

As one of the necessary steps, a limited number of specially designed courses should be developed which require no prerequisites in the particular area, but which do make use of the maturity of the graduate student. Such non-prerequisite courses have been developed in several schools of Business Administration, notably Harvard. Courses of this type might advantageously cut across departmental boundaries. Only a limited number would be needed to initiate such a program, but professors with enthusiasm and high ability are essential for their success. Master's candidates should be encouraged to elect such courses as minors. I personally would hesitate to make them required until their success is proven, and then compulsion should not be necessary.

It is also suggested that programs involving projects in social science might well be developed by individual engineering graduate students. Such a student might study the impact on a community of a new industry, the effect of a change in labor relations, a program of community planning, etc., perhaps tying it up with his own engineering interest. This should be associated with a program of reading guided by an expert in the social sciences.

It is often claimed that intelligent men will broaden their horizons on their own initiative by reading. As an alternative to specific social-humanistic courses, a graduate engineer might be encouraged to engage in such a program of self education. However, to make this effective it would almost surely be necessary to supplement the reading by some planned seminars and to give appropriate credit. Achievement in this area might well be tested by a general examination at the end of the second year of graduate study. We have long accepted a variety of methods of preparing for the language examination for the Doctorate. The candidate may take a course, engage a tutor, travel abroad, or study by himself, provided only that he ultimately passes an examination.

Incentives Necessary

Incentives to the student are undoubtedly necessary for the development of such a program. Our students already feel the requirements for the Ph.D. dedegree are about all that can be borne. However, many engineering students

would welcome an opportunity to prepare for and take an examination in a broad social area in place of one of the presently required language examinations. This is treading on sacred ground, but the necessity of two languages as *tools* is repeatedly questioned. I suggest that the advantages of this program would justify such a substitution. I doubt if we could make a social-humanistic program for the Doctor's degree effective without such a positive incentive. The intellectual level of attainment required for the substitution of an examination in the social sciences or humanities should and could easily be above that required for the language examination.

It is undoubtedly true that any development of such a program will depend greatly upon the support of the faculty advisers to the graduate students—they must be educated first. We cannot expect that legislation alone, academic or otherwise, will produce revolutionary results. Unless there is a coordinated effort by both the graduate school and at least a few of the faculty, nothing will be accomplished. But I do believe that here is an important area for educational development, at present an almost virgin territory, where real effort would bring rich rewards—both immediate benefits and important contributions to the engineering education of the future.

Sections and Branches

The Annual Meeting of the **Allegheny Section** was held at the University of Pittsburgh on April 30 and May 1, 1954. A short business meeting was held on April 30, new officers were elected, and a report on Regional Activities was presented by B. R. Teare, Vice President of ASEE. The following speeches were presented: "The Professional Union—A Contradiction" by Clarence T. Shoch, and "Management Alignment" by William Whigham.

The principal speaker at the Annual Banquet was W. R. Woolrich.

The May 1 session was a general meeting held under the direction of D. G. Schindler, University of Pittsburgh. C. L. Sonnenschein, Young Engineering Teachers Committee, gave a brief report on the work of that committee.

The meetings were attended by 70 members and guests; the banquet was attended by 105 members, guests and their wives.

The **National Capital Area Section** held its Annual Meeting on May 8, 1954, at the Catholic University of America. Bishop Bryan J. McEntegart, Rector of the University, Titular Bishop of Aradi, welcomed the members. After a brief business session, Mr. Henry H. Armsby made a complete report of the Council's activities and submitted a written copy to the Secretary.

Speakers included Mr. R. H. Buescher and Mr. E. K. Von Fange, both of General Electric's Creative Engineering Program. Mr. Von Fange spoke on "Creativeness in an Engineering Program." This was followed by a "brainstorm" session during which about fifty ideas on bringing creativity into an engineering educational program through specific courses were presented by the audience.

Professor J. L. Artley presided at the afternoon session. The winners of the Y. E. T. Prize Paper Competition were introduced. First place—R. M. Adams; Second place—a tie between A. Lawrence Guess and Haaren A. Miklofsky. Professor Adams read his paper entitled "Value Concepts of Engineering Education."

The Resolutions Committee presented its report, and the Nominating Committee presented their slate which was unanimously adopted.

Improving the Teaching of Engineering*

By J. F. DOWNIE SMITH

Dean of Engineering, Iowa State College

Introduction

Several books and pamphlets have been written on the proper planning and organization by the teacher for lecture, recitation, or laboratory instruction, and there is little point to duplication of such writings. This article is directed towards the philosophy involved in the teaching of engineering subjects.

Art to Science

Of the many branches of engineering, at least one (electrical engineering) started out as a science and has continued as a science. Many of the others, however, have slowly evolved from an art towards a science, some having progressed farther than others. The faculties in the field of architecture and architectural engineering have a quite different approach to instruction than some other engineering faculties.

Analysis vs. Synthesis

What has been the effect of this general trend on engineering education? The effect, on the whole, has been good. Engineers today are trained much better than they were 10, 15, or 20 years ago, and there is no comparison at all between what is being handled in college today and what was considered satisfactory 50 years ago. But there is one important major defect in this training, and which should be considered seriously by all teachers of engineering, regardless of the branch they follow. Over the years we have developed in our engineering schools the philosophy that we should teach the student to analyze engineering problems; whereas a large part of his activities in industry will not only be to break down a problem and analyze the individual parts, but to build something from the individual parts. In other words, we must train not only for analysis but for synthesis. This can be illustrated very well in the field of machine design. Where colleges have teachers of machine design who are capable of original design themselves they are extremely fortunate, and the effect on the students must be stimulating. The typical machine design course actually is generally an analysis of machine elements, so that the student who graduates after training in machine design is a man who can take a machine which has been designed by someone else, analyze the various component parts, can find out from his analysis whether the parts are big enough, should be re-designed, should be strengthened, and would work under the conditions mentioned. But he is not trained how to design a machine. This fact has long been evident in industry, and perhaps is one of the most glaring defects in engineering education today. In some industries, indeed, there is a sharp line of demarcation between the engineer who is a trained analyst, and the designer, who is a trained synthesizer. In general, the analysts are college graduates, and in mechanical engineering the designers are frequently, and perhaps even generally, *not* college men, but who have been trained through apprenticeship to other designers in the creation of new machines. The two types are just as separate as they can be. What a tremendous boon it would be to the mechanical industries if they had the combination in one man.

* Based upon talks given at the University of Missouri, February 1, 1954, and Missouri School of Mines, February 2, 1954.

In electrical engineering, however, it is not that way; and most of the designers in electrical machinery and in electrical communications equipment *are* college graduates, who have this ability not only to analyze but to synthesize. Is this traceable to the way the subjects are taught? Or is it traceable, at least to some extent, to the somewhat different philosophy of instruction?

During World War II, an analysis was made of the inventions proposed by people in this country with regard to winning the war. It was a little shocking to find that the correlation between higher education and inventiveness was negative. Is it possible that some of the educational processes which we have actually tend to stifle the inventiveness of the young men? Unfortunately, this is the author's personal opinion. The stifling is partly traceable to the tremendous increase in complexity in the engineering curricula. All engineering educators, perhaps quite naturally, feel that their own particular sphere of interest is extremely important to the student, and thus curricula become so crowded that the student has little time to think for himself. One of the prime problems confronting the engineering teaching profession today is how to eliminate some of the material in the engineering curricula and give the student a chance to think.

Development of Creativity

But there are other ways of doing this with perhaps less chance for major upheaval in the college world; and several institutions are taking suitable steps. For example, a course in design is being conducted at Massachusetts Institute of Technology in which the students are expected to design machines or objects which clearly could not be designed on the basis of copying from previous reports. There is a marked stimulation to the students, who like working on something new.

At Iowa State College machine design students are given considerable latitude, and often choose their own problems. For example, one of those proposed by a student was a machine for dispensing handkerchiefs. All one had to do was insert a quarter, pull a lever, and out would come a handkerchief, wrapped. The machine was patented and is in production. The stimulation to the student was great—so much so that he switched his emphasis from the analytical to the synthetic, and has made a very creditable record as a designer in industry.

Similar experiences were encountered at other colleges where competent designers were available. When Professor Baldwin was at Pennsylvania State College one of his students (a married veteran) came to class late one day and made the excuse that the bottle warmer he needed to heat the milk for his baby didn't work satisfactorily and kept him late. Professor Baldwin asked the student why he didn't design his own bottle warmer, which he did. It was patented, and is now in production.

Why are these isolated cases being brought to your attention? Because a considerable change in philosophy in the teaching of many engineering subjects could be very fruitful. We should not be in the position of stifling the drive and ambition of the young man who comes to college full of energy and enthusiasm. We should encourage it. The architectural schools have been doing it satisfactorily for years. New problems are assigned to the students periodically, and, in general, none has been assigned to any class in previous years. The students sometimes operate individually and sometimes in small groups. But regardless of the size of the unit each proposal is different from the proposals made by everybody else.

Project Method

The architects pride themselves on the fact that they are original. Originality *can* be fostered in college, at least to some extent. Now the architect does this by a project method of instruction, which is quite different from that in most other curricula in engineering, although partly used by some. Most teachers of engineer-

ing would say that this system would not be completely acceptable to them. It could easily be overdone. But a great deal can be achieved by injecting the project method, in small doses, in the teaching of a few of our engineering courses. To illustrate, Professor E. P. Neumann, who teaches thermodynamics at the Massachusetts Institute of Technology, divided his class into two groups. The one section kept on with the regular instruction as it had been outlined, but the second section was told not to attend classes for awhile: they were given, instead, the problem of air conditioning a jet aircraft. Of course, in the process of air conditioning they had to learn the fundamentals of psychrometry and air conditioning, something about heat transfer and refrigeration, the fundamental thermodynamic properties of refrigerant fluids, but they also had to learn something about physiological aspects. What can a man stand? What conditions does he need for comfort? The interesting thing is that these students, who were picked at random from the class, were given the same examinations at the end of the semester as the students who were taking the regular instruction, and there was no appreciable difference in the results of the examinations. But there was a difference in the attitude towards thermodynamics. In addition, because of the necessity to discuss their problems with people of various professional backgrounds it was a broadening experience. Such items, of course, are not limited to mechanical engineering. The electrical engineering students at the same school were treated similarly, and a group of seniors was assigned the task of designing and promoting, commercially, a gas-discharge flashlight for amateur photographers.[1]

Similar approaches have been tried elsewhere, and the logical conclusion seems to be that one of the most effective ways of improving the teaching of engineering is to try to stimulate the students so that he will do his own thinking in *new* problems. We all realize that there are limitations which must be imposed on how far this idea can be carried. In the use of the project method some of the extensive coverage of engineering knowledge *may* be sacrificed, although this has still to be proved. In the limited attempts made so far in various colleges there is no evidence of *any* loss of coverage for senior design classes. But we are constantly reminded of a wise saying, attributed to Professor Rule of M.I.T., "Some teachers try to cover a subject. Actually they should try to uncover a little of it."

Society of Fellows at Cambridge University

Educators have been aware of this general problem for centuries. One solution is the Society of Fellows at Trinity College of Cambridge University in England. This Society of Fellows is an organization which might well be studied seriously by our educators. Trinity is the largest and most famous college of Cambridge University. Its citizens are some seventy fellows, carefully chosen, when young, largely on the basis of their original treatment of a subject in the field of their interest. They are also examined on general knowledge.

To quote from the report:[2] "These examinations are quite different from the examinations of the American university. They are the same for every candidate, regardless of the subject in which he is working, whether mathematics, or philology, or medical science. The questions are always very general, and the candidate is required to write essays on a number of topics chosen freely by him from a long list. For such examinations cramming is impossible. As to substance, wide reading for several years is the only effective preparation. The competition is

[1] See Gordon S. Brown, JOURNAL OF ENGINEERING EDUCATION, December 1952.

[2] George C. Homans and Orville T. Bailey, in the "American Scientist," 1949, pp. 91–106.

not designed to find someone who can fill a particular position. Trinity wants a man, not a peg."

Former President Lowell of Harvard University was very much impressed by the achievement of Trinity College, and, during an inquiry in 1926 into its effectiveness he was given the following statement: "One-half of the British Nobel Prize winners, one-fifth of the several members of the Order of Merit, and four of the five Foulerton research professors of the Royal Society have been fellows of Trinity College, Cambridge. At present, every officer of the Royal Society is a Trinity man. Other honors and distinctions, in almost equal profusion, have, during the past one-half century, fallen to the lot of the fellows and former students of the college of Bacon and Newton, of Dryden, Byron, and Tennyson, of Macauley and Thackeray, of Clerk Maxwell and Rayleigh." [2]

There are other plans of this general nature. All Souls College in Oxford is now nothing but fellows. No strings are attached. A fellow is set free to do his own work in his own way. There is no link with an undergraduate body.

There is a somewhat similar institution in Paris, the Fondation Thiers, where young men, chosen for their promise, are set apart to live in one house, freed from anxieties about their livelihood.

Harvard has also started a Society of Fellows. While the objectives are, in many ways, the same as those of Trinity, it is still too young to determine its effectiveness. There are certain features about the Society of Fellows at Harvard which make it perhaps unique in an educational institution. "A junior fellow is *not allowed* to be a candidate for a degree. The founders of the Society had in mind, particularly, the degree of Doctor of Philosophy. They felt that a Ph.D. degree, with its high but rigid standards and its thorough but routine apprenticeship, provided a good training for many scholars; but that its atmosphere was not always best for the man who was capable of doing individual research and had an idea of his own that he wanted to follow out to the end. Some of the fellows had doctors' degrees when they were elected to the Society. Others have considered it wise to get degrees after leaving the Society. The fact remains that, with or without a degree, fellows have been able to get jobs and good ones." [2]

Such a Society of Fellows, of course, is an ideal situation, and in the typical college or university in this country, and in particular in state universities, the cost of operating such a society would ordinarily be prohibitive. In addition, administrators tend to put more emphasis on academic degrees than is really warranted by the facts.

Motivation

Generally, in order to stimulate creativeness, there has to be motivation, and this can exist at almost any age. For example, the incentive to the invention of the eccentrically operated slide valve for the Newcomen engine was the desire on the part of a 10-year old Scottish boy to play marbles with his friends, and he thus developed an off-center wheel, two pulleys, and a piece of rope to reverse the engine without his help.

Much of this motivation already exists in college students, but insisting that each student go through a fixed and rigorous course of study could readily deaden the motivation, whereas it should be encouraged.

Mass Production

One of the principal objectives of higher education is to stimulate the student so that his mind is capable of contributing something new, as well as handling those problems which come up every day. Our training in college is not always conducive to the promotion of scholarship or creativeness. Professor William E. Hocking describes [3] some of the training in European universities and how it differs, to some extent, from what we do here. He stated as follows: "Years ago, Professor Levy-Bruhl spent some time at

[3] *Higher Education*, January 15, 1950.

Harvard University. On one occasion he remarked to me on the number of hours of lecturing time spent by the American college teacher. 'In America,' he said, 'you respect scholarship, but you do not respect the conditions of scholarship. At home in Paris I gave two lectures per week. The rest of my time is for my own study and writing.

'The American situation results, in part, from the immense educational undertaking, of which we have spoken; in part, from the system of bookkeeping necessary to give an honest value to diplomas delivered in thousands; in part, from immaturity of purpose in the American college boy. Unless the student has his own mental initiative, and, therefore, his own questions, the labor of the instructor is first to raise the appropriate question in his mind, and then to supply the answer.

'The end is mental power, and power cannot be tested by the ability of any student to answer *my* questions. It must be tested by the ability of the student to frame his own questions and to devise his own way to an answer. I submit to the American method; but its very laboriousness for the teaching staff is in grave danger of defeating its own end—the development of power in the student.'"

The Social Humanities

We are all aware of the continuing pressure from all directions to increase the content in the engineering curricula. Thus there has been pressure to put into effect in engineering a five-year curriculum to permit absorption of this increased knowledge. This, at the moment, does not seem to be the proper solution.

There has also been a tendency to increase the social humanity subjects in engineering. That these subjects are important, when properly taught and assimilated, is unquestioned. But we can't keep putting into engineering curricula more and more subjects without taking something out. There has been constant, understandable, opposition from each of the various disciplines when it is proposed that that discipline be reduced or eliminated.

A possible solution has been presented by President Virgil Hancher of the University of Iowa.[4] Many others in the past have stated somewhat similar views, but none quite so clearly as the statement by Dr. Hancher. In summary, he stated that the two principal contributions to higher education in America were the land-grant college and the four-year liberal arts program. This four-year liberal arts program does not exist anywhere else in the world, according to Hancher, except where it has been established by Americans or other persons having before them the model of the college of liberal arts as it developed in this country. For example, if a man wants to study law in Great Britain, his liberal arts training is combined with the law in such a way that he gets both; and, according to Hancher, "The study of law (at Oxford University) was as certain a means of becoming liberally educated as the pursuit of any academic major in any college of liberal arts in this country, either at that time or since." The same thing is true of medicine, and of engineering. It is probably true that the average student in a European university is somewhat more mature mentally than the average American college student, and there is unquestionably a more rigorous training in high schools in Europe than in many American communities. For example, in a major technical college in Scotland, there is no instruction in liberal arts subjects as such. Of course, before going to college the students would have to pass examinations in many subjects including English, one, two or three foreign languages, mathematics, history, and so on. Thus, it might be assumed that at least some of the social-humanity subjects had been taught adequately in high school. But there is a distinct possibility that we may be doing a disservice in this country by classifying the liberal arts as a disci-

[4] Hancher, Virgil, JOURNAL OF ENGINEERING EDUCATION, March 1954.

pline entirely separate from engineering. Is there any reason, for example, why a teacher of engineering could not inject the liberal arts into his instruction? If an engineer is getting into the design of bridges, couldn't a history of bridge builders in the past be brought in at the same time, showing the developments of men like Roebling, and the influence they had on civilization. While teaching thermodynamics, would it not be perfectly feasible to bring in a little of the romance which is attached to the steam engine, the turbine, the gas turbine, jet propulsion, space flight, and so on, showing the effect of each development on the profession and on the community. It might be argued, justifiably, that this would reduce the technical content of the course, although this would have to be proved.

But even if it were true, are we not trying to help the student cover too much with the time at his disposal? We ordinarily give the student in engineering such a concentrated dose of technical facts that a leavening of this type might well be desirable. It is quite possible that by proper cooperation with the other faculties in the social humanities, a valuable exchange of information might be obtained. Many educators are opposed to having engineers take a course in a liberal arts subject which is really a prerequisite for a major in that field. Ordinarily the engineer does not get out of it what the engineering profession thinks he should. But we *could* inject certain of the humanities into our engineering instruction. It may be objected, rightly, that our engineering faculties are not competent to teach engineering subjects with suitable doses of the social humanities injected. This is probably true; but is it not possible that the engineer could learn? This, then, might be a place for our mature graduates to study some of the social-humanities intensively themselves, and bring those studies to bear in the broadening of the teaching of the engineer.

One might draw the conclusion from some statements in the literature that nothing less than the direct teaching of cultural subjects, without vocational purpose, could save us. But other thinkers have spoken rather differently.

A. N. Whitehead wrote:[5] "The antithesis between a technical and a liberal education is fallacious. There can be no adequate technical education which is not liberal, and no liberal education which is not technical."

Sir Fred Clarke wrote:[6] "An adequate philosophy will transcend the popular distinction between the cultural and the vocational."

Engineers must be made aware of the social implications of their work, and this may be partly accomplished by the incorporation in our engineering instruction of the broad liberal approach.

Regional Training of Engineers

It is also clear that in some fields we cannot improve the caliber of instruction in engineering because of the limited number of students involved in a department. It is always difficult for the administration to justify spending large sums of money for laboratory equipment for a relatively few students. It is possible, then, that in the near future we must consider more regional training in certain fields where instructional costs are, at the moment, high. This has been started in the south and apparently operates satisfactorily in such fields as veterinary medicine. There is no reason why this might not also be developed in engineering. It certainly would be one way of improving the teaching in certain curricula. The political implications must be faced sooner or later.

Summary

In summary, it is the opinion of the author that some improvements in the teaching of engineering subjects may be achieved by study, and the application, of good teaching methods, as explained in

[5] A. N. Whitehead, "The Aims of Education and Other Essays."

[6] Sir Fred Clarke, "Freedom in the Educative Society."

many texts now available. But a major improvement might be obtained by changing the philosophy and analysis of engineering teaching, even if this change in viewpoint might apply to a limited number of courses in each curriculum. In particular, we must pay more attention to the development of the potentially creative engineers. In addition, we should consider possible improvements by pooling the efforts of many of our universities and colleges.

In the News

EJC Convocation on Nuclear Engineering

To meet "the pressing problems of nuclear engineering and the related sciences," with particular interest in "industrial usefulness," **Engineers Joint Council**, composed of major American engineering societies with a total membership of 170,000, today announced initial steps toward an organized program of confronting these problems "authoritatively by a group of leading engineers."

In making the announcement, Thorndike Saville, President of the Council and Dean of Engineering at New York University, commented that "action by this powerful engineering group is further evidence that nuclear energy is well on the way to having important peace time industrial usefulness." The likelihood that physicists, chemists and others will be invited to join the engineers, as their organization develops, was indicated by Warren L. McCabe, Administrative Dean at Brooklyn Polytechnic Institute, Chairman of Engineers Joint Council Committee on Recognition of Specialities in Engineering. The movement is expected to bring together most of the country's eminent participants in industrial nuclear development.

Although organization of the new group is in its initial stages, a national convocation in 1955 is contemplated for discussion of the subject of nuclear development for industrial use.

The announcement was as follows:

"The pressing problems of nuclear engineering and the related sciences are to be dealt with authoritatively by a group of leading engineers. In this announcement, Thorndike Saville, President of Engineers Joint Council, is joined by Daniel V. Terrell, President of the American Society of Civil Enginers; Leo F. Reinartz, President of the American Society of Mining and Metallurgical Engineers; Lewis K. Sillcox, President of The American Society of Mechanical Engineers; Alexander C. Monteith, President of the American Institute of Electrical Engineers; Chalmer G. Kirkbride, President of the American Institute of Chemical Engineers; Dale L. Maffitt, President of the American Water Works Association; W. E. Blewett, Jr., President of the Society of Naval Architects and Marine Engineers, and N. W. Dougherty, President of the American Society for Engineering Education, who, under the auspices of Engineers Joint Council, have taken steps to organize the cooperation of all engineering groups and related scientists to develop discussions of nuclear engineering subjects and to deal with the publication of worthwhile papers and addresses."

The total membership of the federated societies known as Engineers Joint Council is about 170,000. The membership includes several thousand skilled engineers who are working on the critical problems of mining, processing and the use of all the materials involved in the production of energy by fission. Action by this powerful engineering group is further evidence that nuclear energy is well on the way to having important peace time industrial usefulness. As to the likelihood of an invitation to others to join the engineers' program, Dean McCabe said:

"We agree as to the desirability of bringing in the physicists, chemists and perhaps other related groups, but at the moment our responsibility is largely in the engineering field."

Lamme Award—1954—Thorndike Saville

To THORNDIKE SAVILLE *for his distinctive leadership in organizations for the advancement of the engineering profession and of engineering education, for his valued service to the American Society for Engineering Education in numerous capacities including its Presidency in 1949–50, for his distinguished contributions to*

engineering education as an educator and administrator, for his untiring service to ECPD as Chairman of its Committee on Accreditation, for his leadership in the Engineers' Joint Council during its reorganization and as its President in 1954, for his engineering contributions and wise counsel to governments in the fields of water supply, beach erosion, sanitary engineering and water power, we award this twenty-seventh Lamme Award.

THORNDIKE SAVILLE was born in Malden, Massachusetts on October 3, 1892, the son of Caleb Mills Saville, who was a Division Engineer under General Goethals on the Panama Canal, and later became chief engineer of the Metropolitan Water Bureau of Hartford, Conn., and Elizabeth Thorndike Saville. His secondary school education was received in the schools of Malden and Brookline, Mass., and on the Panama Canal. He received the bachelor of arts degree from Harvard and the degree of B.S., *magna cum laude*, from Dartmouth College, both in 1914. In 1915, he was granted the C.E. degree from Dartmouth's Thayer School of Engineering. Before entering the Army in 1917, he was awarded the degree of M.S. both from Harvard and M.I.T. Clarkson College of Technology in 1944 and Syracuse University in 1951 awarded him the honorary degree of Doctor of Engineering.

As a first lieutenant during World War I, he directed design and partial construction of the Big Bethel Water Supply and Filtration Plant for Langley Field and Fort Monroe and supervised construction of the sewerage and drainage systems at Langley Field. After the war, he investigated river regulation and sewage treatment processes in England and France under a Sheldon Traveling Fellowship from Harvard.

In 1919, with his appointment by the University of North Carolina as associate professor, later professor of hydraulic and sanitary engineering, Dr. Saville began a career of engineering education achievements that were to parallel significant contributions to engineering, research, and community service. Today, he is the dean of the College of Engineering at New York University; president of the Engineers Joint Council; a member of the U. S. Beach Erosion Board; chairman of the Committee on Education, ECPD; engineer member of the New York State Public Health Council; and consultant to the Long Island State Park Commission.

As engineer and citizen, Dean Saville has devoted a lifetime to the conservation and judicious use of the nation's natural resources, particularly its water reserves. His early work in the statistical analysis of river flow proved valuable in flood control and river and stream pollution projects. In 1931, he wrote a comprehensive description of the power situation in the South, describing the growth and future possibilities of hydro-electric developments in southern states and which the American Academy of Political and Social Science published. For the National Resources Board in 1935, Dean Saville made an inventory of the nation's water resources. In 1926 the Rockefeller Foundation sent him as a consultant to the government of Venezuela to investigate the water supply for Caracas.

He has originated, carried out or directed studies in stream gauging, beach erosion, underground waters, rainfall, floods, evaporation, and silting. A few of the subjects covered in his many publications include the administrative control of water pollution; methods of estimating flood flows; national planning for coastal protection; and the nature of color in water.

In 1932, New York University appointed him professor of hydraulic and sanitary engineering, three years later named him associate dean, and in 1936, dean of the College of Engineering. At New York University his policies have extended the range of undergraduate instruction and encouraged academic and sponsored research that enlarges the opportunities for advanced engineering education while at the same time adding to

the store of scientific knowledge. His academic programs have particularly raised to major status the fields of sanitary science, meteorology and oceanography, and engineering physics.

Dean Saville was early in recognizing the possibilities of cooperation between institutions of engineering education and the municipality and other publics, including regional industry. He was instrumental in the joint construction, with the city of New York, of the Lewis Van Carpenter Sanitary Engineering Research Laboratory at New York University.

Appreciating the interdependence of the arts and sciences in the modern world, Dean Saville has also promoted several cooperative programs with liberal arts colleges.

His abiding interest in the student begins at orientation programs, before the freshman walks into his first class—and continues long after the granting of a degree, as thousands of alumni will testify. He is known to devote the same penetrating thought and incisive expression to a message in a student publication as to an address to colleagues.

Dean Saville's efforts toward improving the status and quality of the engineer and his profession is reflected in a record of long and untiring service in numerous activities of the A.S.E.E., the Engineers Council for Professional Development and the A.S.C.E. He was president of the A.S.E.E. in 1949–50, president of the Metropolitan Section of A.S.C.E. in 1937–43, and a director of the Society from 1945 to 1948. Engineering education owes an enduring debt to his pioneering labors in the establishment of basic and authoritative accrediting policies and procedures. In 1953, Dean Saville represented the engineering societies of the United States at the Conference on Engineering Education in London conducted by the Engineering Societies of Western Europe and the U. S.

Among his other associations have been Chief Engineer of the North Carolina Geological Survey; consultant to the U. S. Geological Survey and the Mississippi Valley Committee investigation of flood frequencies; member, Governor's Technical Advisory Committee, New York State Department of Commerce; member, National Advisory Committee, Engineering Science and Management War Training; advisor to the Public Works Committee of the first Hoover Commission; consultant to the National Science Foundation; chairman, Engineering Panel on Water Supply for New York City; member of the National Advisory Health Council, U. S. Public Health Service.

Dean Saville's career is fulfillment in a larger sense of the philosophy of an engineer as he expressed it recently in writing to students: "The elements of true creation, imaginative and sage design, public responsibility, and ethical practice are inherent in the individual, waiting to be activated by precept of the instructor and by intellectual and spiritual growth based upon, but not automatically resulting from a broad and sound education."

In the News

A total of 176 research projects supported by funds amounting to $400,516 are now under way in the various laboratories of the **University of Wisconsin College of Engineering**, the 1953–54 report of the Engineering Experiment Station, published today, reveals. The research projects, all highly technical, cover a wide variety of engineering problems ranging from "Condensation of Vapor as Ice" in chemical engineering to "Methods for Improving the Ductility of Concrete" in the mechanics department.

George Westinghouse Award—1954—
Thomas James Higgins

To THOMAS JAMES HIGGINS *for his tireless efforts in the interests of better teaching; for his capacity to stimulate others in the classroom, in committee meetings, and in meetings of professional groups; for his many published papers, critical reviews, and offerings in technical conferences; for his effective contributions*

to undergraduate education, to graduate education, to research; for his genuine thoughtfulness of others; and for his unswerving devotion to the teaching profession, we award this ninth George Westinghouse Award.

THOMAS JAMES HIGGINS was born in Charlottesville, Virginia, on July 4, 1911. He attended Cornell University, receiving the degree of Electrical Engineering (E.E.) in 1932, and in June of 1937 the M.A. degree in Mathematics. From Purdue University he received the Ph.D. in Electrical Engineering in 1941. During his four years at Purdue he was an Instructor in Electrical Engineering while diligently pursuing the Ph.D.

His other teaching experience includes one year at Auburn Intercollegiate Center (1933–34), two years at Wyomissing Polytechnic Institute (1935–37), one year at Tulane University (1941–42), and six years at the Illinois Institute of Technology (1942–48).

His industrial employment includes short periods with Ebasco Services, Inc., Agfa-Ansco Corp., City of Ithaca, Associated Gas and Electric Corp., Wenderly Construction Co., and Fuller Construction Co. He is a registered engineer in Illinois and Wisconsin, and does consulting engineering in the fields of heavy-current bus bar distribution system design, and in automatic control theory analysis.

It was in his junior year in college that he decided to make teaching his vocation. He has never swerved from this decision nor consciously neglected any means of preparing himself to this end. Those of us who know him well fully appreciate the sincerity of this early decision and the complete devotion and zeal with which Dr. Higgins pursues his objective.

During his teaching career, he has taught courses covering practically all of the material which one finds in the modern undergraduate curriculum in Electrical Engineering. Since coming to Wisconsin in 1948, he has outlined and taught five new graduate courses in electrical engineering. These courses embrace thorough coverage of material in the theory of nonlinear electric circuit analysis, matrix and tensor theory of electric networks and machines, modern operational methods of electric circuit analysis, and both basic and advanced servomechanism and automatic feedback control theory.

As to research and publications, Dr. Higgins has indeed attained distinction. His published works to date are approximately ninety in number. They cover a broad range of interests, including a particular emphasis on the analytic solution of a variety of problems in electrical engineering. As one interested generally in biography and history, and especially as they relate to science and engineering, he has published several exhaustive bibliographies listing the available booklength biographies of men of science and technology in a number of different fields, as well as a recent detailed bibliography of books and papers devoted to the history and development of electrical engineering and electrophysics. He has contributed to several abstracting journals and has edited a number of books for different publishing houses.

He was married to Louise Logan of Indianapolis on April 5, 1942. Mrs. Higgins, a graduate of Earlham College, possesses a combination of sparkling humor, easy nature, and ready understanding which contributes much to their home and social life. They have two children, Janet and James, eight and four years of age, respectively.

Dr. Higgins' honorary and professional association include Eta Kappa Nu, Sigma Xi, AIEE, ASEE, NSPE, AAUP, Mathematical Association of America, and the Wisconsin Society of Professional Engineers. His committee activities and responsibilities in these organizations are many, and thus to most of these he has contributed much time and effort.

THE T-SQUARE PAGE

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DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

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Laying the Foundation for Engineering Graphics

By J. G. McGUIRE

Professor of Engineering Drawing, The Agricultural and Mechanical College of Texas

As we lay out our programs in drawing for the beginning engineering college student, the question arises: "Where shall we start and how shall we proceed in directing the efforts of the young engineering student as he builds a working background in graphical procedures?" In particular, this question arises when the time allowed is very limited for developing in the student the ability to use graphics as effectively as he is taught to use mathematics. Also, the question arises when we see many students come to engineering college with some background in drawing while others have had no experience with drawing nor any knowledge of the instruments and equipment associated therewith.

Is it possible or desirable to start all beginning college students at a level low enough for those with no experience and spend a semester building a background in lettering and simple views? For those students who have gained this experience in high school, such a program can be quite exasperating. Also, for the student with average or above ability but with no previous drawing experience, a program that does not advance fast enough into college grade material can waste a lot of valuable time.

Integrated Program

It would seem possible to build an integrated program which advances into the elements of descriptive geometry during the first semester that will serve all entering students who have average or above ability regardless of their previous experience in drawing. Under such a program the student can be familiarized during the first semester with most of the principles of drawing that are commonly reserved for descriptive geometry, with at least a part of the second semester devoted to applications designed to suggest to the student how graphics may be used as an analytical tool on a footing equal to that of mathematics.

A program that would provide for such progress during the student's first year in college drawing would demand that the principles of descriptive geometry be carefully integrated with the material in the basic drawing course. In this way it would appear that much du-

plication could be eliminated. As an example, possibly equal results could be obtained by the elimination of much of the drill on completion type problems of obtaining the third view of complicated mutilated blocks and placing emphasis on *realtionship of views, lines of sight,* and *reference planes* while teaching some of the basic principles of descriptive geometry. Not only would there be considerable elimination of duplication of effort on many items but the student would come to think of the principles of descriptive geometry as more closely related to those of basic drawing and he would be less reluctant to call upon these principles in the solution of problems that may lend themselves to graphical solutions.

Of course such a program would demand that some of the weaker students be given a more elementary and possible non-credit course in preparation for the integrated course. But the division should not just be a separation of those students who have, from those who have not, had high school drawing. It seems likely that the majority of students who have had no drawing would be quite successful in the integrated program and gain a background in graphical procedures more nearly comparable to their training in mathematics at the end of their freshman year.

Meeting Notices

ECPD Annual Meeting—Cincinnati, Ohio, October 28–29, 1954, Alms Hotel.

Subject: The First Five Years of Professional Development.

ASEE General Council—Cincinnati, Ohio, 6:00 P.M., October 27, 1954, Alms Hotel.

ASEE Technical Institute Division—Committee of Twenty One and Chairmen of Committees, Cincinnati, Ohio, October 27, 1954.

Report of the Secretary, 1953-54

It is a pleasure to present in this annual report an outline of several new projects which have been undertaken by the ASEE during the current year. These penetrate deeply into many of the principal problems of engineering education and show promise of making substantial long-range contributions to the work of the Society.

The project Evaluation of Engineering Education, which is entering its second year, has aroused widespread participation among faculty members in engineering colleges throughout the country. It has served to turn the attention of engineering educators ahead to an evaluation of the future needs of the profession, with due consideration to the rapid changes taking place in a number of fundamental areas of science and technology.

A significant project, initiated this year, is the Humanistic-Social Research Project. This will focus attention upon the development of quality educational programs in the Social Sciences and Humanities. The Summer Institute program, also launched for the first time this year, is off to a good start. It includes two conferences dealing with Solid State Physics in Engineering Education and Nuclear Science in Engineering Education. Plans are being made for Summer Institute Conferences of a similar character for next year. This year, the Society is sponsoring six Summer Schools, the largest number in its history. Another project, currently in the formulative stage, is a comprehensive evaluation of the curricular goals and objectives of graduate study. This project has considerable significance, in view of the substantial growth of graduate programs and the rising graduate enrollments.

Various Committees and Divisions of the Society are currently devoting a great deal of attention to exploring the newer developments in science and technology and in trying to interpret these in terms of their influence upon engineering education in the years ahead. Experience has repeatedly shown that newly developing areas illuminate the more traditional fields and concepts with new ideas and new fundamental analytical approaches. This type of evolution has brought about much of the progress in engineering education. It is in this area of operation that the Society can serve its highest function by providing a national forum to bring together divergent viewpoints and subject them to critical analysis.

A considerable amount of attention is currently being devoted to two other aspects of engineering education. One of these is the possibility of developing closer integration of course material. The objective here is to help the student to see similarities in the analytical methods of approach in many diverse fields. This would give him a broader perspective and a deeper appreciation of the underlying unity of the physical sciences. The second area of general interest is that dealing with means of developing the student's latent powers of resourcefulness and creative ingenuity. Engineering is basically a creative profession and it seems imperative that engineering education should produce individuals who have a creative outlook in life. Unfortunately, there are no simple solutions to these problems. To achieve results in these areas requires critical analysis of objectives to be sought and soundly conceived experimentation.

Evaluation of Engineering Education

The ASEE Committee on Evaluation of Engineering Education presented at

the Annual Meeting its Interim Report, representing a thorough reappraisal of engineering education in the light of the needs of the profession in the years ahead. This report is based upon recommendations of over 118 institutional committees. It is expected that this Interim Report will be allowed to stand for approximately a year and will then be revised in the light of further recommendations of the institutional committees. In the meantime, the institutional committees will be asked to prepare their own analyses. Bound copies of these reports will be placed in engineering libraries throughout the country, as representing the current thinking on trends in engineering education.

A meeting of a number of leading industrialists brought forth many exceedingly helpful viewpoints which have clarified industry's views on the trends of engineering and engineering education in the future.

Copies of the Interim report can be obtained by writing to the Secretary of ASEE. The price is 20¢ each or 12¢ each in quantities of 100 or more.

Humanistic-Social Research Project

Ten years ago, the Report on Investigation of Engineering Education After the War set forth an urgent recommendation that steps be taken to improve that portion of the engineering curriculum dealing with the humanities and social sciences. A great deal of a general nature has been written about this need and many platitudes have been voiced. However, only a few schools have undertaken a comprehensive analysis of this area of education with a view toward developing a well-integrated program of courses. For the most part, engineering colleges have appropriated existing courses in the liberal arts schools.

It now seems timely to conduct a serious and penetrating analysis of this important area of instruction. This will be the objective of the Humanistic-Social Research Project, initiated this year under a grant of $30,000 from the Carnegie Corporation. The project will be directed by Dr. George A. Gullette, North Carolina State College. The Chairman of the Committee will be Dr. E. S. Burdell, President of The Cooper Union.

This project will seek out and analyze those ideas, courses, programs, and procedures which appear to be well-conceived and which show fresh and imaginative approaches. The project will not only analyze existing programs, but it will also project ahead and develop its own recommendations for course material and curricular improvement. This will be a two year study. Preliminary studies are now under way.

Summer Institute Program

A new innovation this year is the Summer Institute Program. Its purpose is to organize conferences in critical areas of engineering education where there appears to be a possibility of making substantial improvements. Some of these areas deal with rapidly developing fields of scientific and technological knowledge which appear to be very fundamental and which have a substantial bearing upon engineering of the future. Others may deal with the unification of subject matter which cuts across curricular boundaries.

This year, two Summer Institutes have been planned. One will be in Solid State Physics in Engineering Education, to be held at Carnegie Institute of Technology, June 21–25, 1954. The other in Nuclear Science in Engineering Education will be held at Northwestern University, September 7–10, 1954. Both of these Summer Institutes will attempt to get a clarification and logical organization of fundamental concepts. They will assess the material as to its importance in engineering education and seek logical and orderly patterns for teaching purposes. It is hoped thereby to reduce substantially the amount of time lapse in translating new fundamental concepts into engineering education and engineering practice.

The two Summer Institutes this year

were financed by grants totaling $15,500, from the National Science Foundation. Each Summer Institute was preceded by a closed conference in which leading authorities in research and education gathered to discuss the material. The closed conference for the Solid State Physics was held at the University of Illinois. The closed conference on Nuclear Physics in Engineering Education was held at Columbia University.

Summer Schools

This year the Society is sponsoring six Summer Schools, the largest number in its history. These Summer Schools are as follows:

Engineering Economy Committee—Evaluation of Analytical Techniques of Engineering Economy
Electrical Engineering—Elements of Design of Digital Control Circuits
Humanistic-Social—Workshop for Humanistic-Social Research Project
Engineering Mechanics—Evaluation of Graduate Training in Mechanics
Mechanical Engineering—Teaching of Machine Design and Manufacturing Processes
Educational Methods and General Electric Company—Teaching Methods Seminar

In addition to these, the Instrument Society of America will hold a one-day meeting jointly with ASEE at the Annual Meeting in Urbana.

Young Engineering Teachers' Activities

The YET movement in the Society has gained great momentum as a consequence of steps taken by Divisions and Sections of the Society to bring young teachers into active participation. This year the YET Committee has been responsible for the membership campaign. This has resulted in approximately 400 new members in the instructor and assistant professor ranks.

The YET movement holds great promise both for the future of the Society and also in providing opportunities for the professional growth of young engineering teachers. Many engineering colleges now have YET organizations. They provide a pleasant social experience and a means of enabling young faculty members to take hold of the principal problems facing engineering education and broaden their outlook and perspective. Many of the Sections of the Society now have half-day meetings organized entirely by the YET's.

Again this year the Society is sponsoring a paper contest for young engineering teachers. The awards will be given at the Annual Banquet. Last year there were 75 entries in the YET Contest.

The Fall Meeting of ASEE–ECPD

The Fall Meeting of ASEE–ECPD was held at the Statler Hotel in New York in October. The ASEE portion of this program, arranged by ECRC and ECAC, featured a conference on Creative Thinking, with speakers who themselves are eminently creative in the fields of music, art, writing and scientific and engineering research. This conference created a great deal of interest in a field which merits further investigation.

Another portion of the program dealt with the problems and policies of accreditation of engineering curricula. Approximately 400 educators and professional engineers attended this meeting.

ECRC Activities

The ECRC this year published its Review of Current Research, listing principal research activities in progress in engineering colleges throughout the country. ECRC also has been working on a policy statement regarding research in engineering colleges.

ECAC Activities

The ECAC Manpower Committee is actively studying the supply and demand of engineering manpower and the problems as they relate to military demands on engineering manpower. Other ac-

tivities of ECAC will be summarized in the Committee's Annual Report.

The Military Affairs Committee of ECAC has been actively studying a number of phases of the ROTC problem, including the implications of the reduction of Air Force ROTC quotas.

The Selection and Guidance Committee of ECAC is currently working with the Educational Testing Service in devising tests as selective instruments for employers. A pilot run will be made in a few colleges. They are also endeavoring to construct a placement test which will indicate to senior students their own interests and aptitudes.

The Committee on Secondary Schools of ECAC is currently working with other professional and educational societies in an attempt to find a means of improving high school preparation of engineering students. This is a difficult problem, since it is complicated by the shift in high schools toward general education and also by the exodus of good science and mathematics teachers from schools into industry.

Graduate Study Proposal

The Society is currently considering a new project to investigate the objectives and curricular organization of graduate study. There has been very substantial growth in graduate work in all curricular areas over the past ten years and there is every indication that this growth will continue in the years ahead. The Society has never made a thorough study of curricular goals at the graduate levels of instruction.

Associate Institutional Memberships

This year, the Associate Institutional Membership Drive, under the able Chairmanship of Mr. Jesse McKeon, added its one-hundredth Associate member to the Society rolls. These Associate Institutional Members are companies, all of which have substantial engineering operations. This program of cooperation between engineering education and industry, which started with the formation of the ASEE Division of Relations with Industry, has proven of great benefit both to industry and to the colleges.

Dues Amendment

The amendment to By-Law IV, which was submitted to the Society in April, 1954, passed by a 76% vote. This provides for a nominal increase in dues next year, the dues being $8.00 for members over 36 years of age and $6.00 for those under. This will make it possible to operate the Society with a small margin of revenue.

Division Publications

The Society membership owes a deep debt of gratitude to the individuals in the Divisions who were responsible for the publication of the various technical journals published by the Divisions. These publications serve a vital role in bringing to the engineering teachers helpful information on methods of improving their teaching. They are all operating on a self-financing basis and even the advertising is solicited by the Division officers. There is little glory but great returns in doing this kind of a job.

The Technical Institute Division came through with two very helpful publications, "The Engineering Technician" and "Literature Significant to Education of the Technical Institute Type." These will prove extremely useful both to the teachers in this field and the students who are contemplating technical institute level education.

The Relations with Industry Division held a highly successful conference in Detroit on the subject "The First Five Years After Graduation." This is a problem of professional development of young engineers in industry, aimed at expanding educational opportunities and means of professional growth of the young engineer.

Cooperation with Other Organizations

During the past year, the ASEE continued its active participation with Engineers' Joint Council, Engineers' Council

for Professional Development, American Standards Association and many other organizations. The President of EJC this year is Dean Thorndike Saville, our ASEE representative to EJC. The ASEE will have three representatives attending the UPADI meeting of engineers of the western hemisphere in Sao Paulo, Brazil, this August. President Grinter and Dean Saville will both attend the EUSEC meeting on engineering education in Switzerland in the Fall of the year as representatives of ECPD. The travel expenses for their representation have been provided without drawing upon Society funds.

Respectfully submitted,

ARTHUR BRONWELL, *Secretary*

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

ENGINEER WANTED—ORGANIZATION planning establish research fellowship for study of land use, conservation and rehabilitation wishes contact graduate civil engineer age 25 to 35, preferably some experience gravel economics and operation with imagination and interest in landscape engineering. Objective eventual specialized consulting association. Location eastern states. Reply box S1.

ASSISTANT PROFESSORS (2) OF Electrical Engineering. University of North Dakota, Grand Forks, No. Dak. Duties: One man to teach electronic and communication courses, and one man to teach electrical power courses to undergraduate students. Appointments to begin in September 1954. An advanced degree plus some teaching or industrial experience preferred. Submit resume of education and experience to Head, Electrical Engineering Department.

IN MEMORIAM

KARL TAYLOR COMPTON

1887–1954

Dr. Karl Taylor Compton, President of the American Society for Engineering Education in 1938–39 and its Lamme Medalist in 1949, and President of the Massachusetts Institute of Technology from 1930 to 1949, died in New York on June 22, 1954.

As Chairman of the Corporation, the post he held at M.I.T. since 1948, Dr. Compton had participated in his customary gracious manner in the Institute's 88th commencement exercises on June 11 and in the alumni reunions of the following weekend. In New York on June 16, he was stricken with a heart attack and died five days later. A memorial service at M.I.T. on June 25 was attended by hundreds of alumni, leaders in science and education, and representatives of governments and learned societies.

As M.I.T.'s ninth President, he was responsible for a broadening and enrichment of the curriculum, adding new courses and rearranging others as he anticipated the needs of industry and society in a changing world. With the Division of Humanities at M.I.T., Dr. Compton introduced to the Institute a new concept of the values of science and engineering in the advancement of civilization. He sought to balance a precise training in the professions by adding studies of their wide social implications, so that students of science, engineering, and architecture might also learn to participate intelligently in social and economic affairs.

In 1937, during this period of developing educational philosophy, Dr. Compton was elected Vice-President of the Society for the Promotion of Engineering Education and one year later became its President. Earlier, he had served as a member of its Committee on Graduate Studies (1931 to 1933) and as a member of the Council (1933 to 1936); later he continued service on the Council from 1939 to 1946. Dr. Compton was Chairman of the Society's Committee on Engineering Manpower in 1946.

In later years Dr. Compton's generous contribution of time to public activities led him away from M.I.T.—and eventually to give up its Presidency several years before the nominal retirement age. This record as a public servant is too extensive to be detailed here. During World War II, as a member of the National Defense Research Committee, he joined a group of brilliant men in directing a military research program of unparalleled scope and achievement. Indeed, as Dr. Killian pointed out in the memorial broadcast, so great was Dr. Compton's contribution that his citation for the Medal of Merit included the "extraordinary statement that he personally was responsible for shortening the duration of the War."

Dr. Compton was born in Wooster, Ohio, on September 14, 1887, and received the Ph.B. in 1908 and M.S. in 1909 from the College of Wooster. He served for one year as instructor in chemistry before entering the Graduate School at Princeton, where he was awarded in 1912 the Ph.D. degree summa cum lauda. In 1915, after three years as physics instructor at Reed College, Dr. Compton was recalled to an assistant professorship at Princeton, where he remained as Professor and later as Chairman of the Department of Physics until 1930.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 17, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Polytechnic Institute	Dec. 4, 1954	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	April 2, 1955	M. M. Jones, University of Missouri
National Capital Area	Catholic University	Oct. 5, 1954	J. C. Michalowicz, Catholic University
New England	Massachusetts Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	A. F. Inst. Wright Field	Sept. 17–18, 1954	K. F. Sibila, University of Akron
	University of Akron	May 7, 1955	
*Pacific Northwest	Oregon State College	Spring, 1955	M. L. Jackson, University of Idaho
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1954	B. M. Green, Stanford University
*Rocky Mountain	University of Utah	Fall, 1954	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9 1955	V. L. Doughtie, University of Texas
Upper New York	Cornell University	Oct. 22–23, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

ADAMS, RICHARD CALVIN, Instructor in Mechanical Engineering, Pennsylvania State College, State College, Pa. H. L. Dillenbeck, M. S. Gjesdahl.

ALEXANDER, CLAUDE H., Coordinator of Technical Service, B. F. Goodrich Chemical Co., 324 Rose Building, Cleveland 15, Ohio. L. M. Freeman, A. Syverson.

ANDERSON, QUENTIN L., Training Coordinator, Fisher Body Cent. Eng. Activities, Detroit, Michigan. E. C. Flarity, S. J. Hirschfield.

ANTHONY, RICHARD LEWIS, Chief Mechanical Engineer, Westcott & Mapes, Inc., New Haven, Conn. W. J. Wohlenberg, G. Robley.

BATTEAU, DWIGHT WAYNE, Assistant Professor of Engineering, Harvard University, Cambridge, Mass. C. H. Berry, C. L. Daives.

BAUGHMAN, GEORGE H., JR., Instructor of Engineering, Drexel Institute of Technology, Phoenixville, Pa. C. A. Kapp, S. B. Collins.

BEERS, YARDLEY, Associate Professor of Physics, New York University, New York, New York. H. Torgerson, D. B. Porter.

BERRY, DONALD S., Professor of Engineering, University of California, Berkeley, California. H. E. Davis, R. A. Moyer.

BETTER, BERNARD RAYMOND, Director of Research, Scully-Jones and Co., Chicago, Ill. L. E. Doyle, K. J. Trigger.

BLACK, HAROLD LISLE, Professor of Engineering Research, Pennsylvania State University, State College, Pa. C. H. Tindal, Arthur T. Thompson.

BLACKBURN, JACK BAILEY, Research Engineer, Purdue University, Lafayette, Indiana. C. Lovell, Jr., M. B. Scott.

BOND, THOMAS HOBART, Assistant Professor of Engineering, State University Maritime College, Glen Cove, New York. J. J. Foody, A. O. Porter.

BOODLEY, NANCY KESTER, Instructor of Engineering Drawing, Pennsylvania State University, State College, Pa. H. L. Dillenbeck, M. S. Gjesdahl.

BOUDREAUX, FELIX JOSEPH, Associate Professor of Electrical Engineering, Southwestern Louisiana Institute, Lafayette, Louisiana. H. R. Mason, R. E. Jenkins.

BRASUNAS, ANTON DESALES, Assistant Professor of Chemical Engineering, University of Tennessee, Knoxville, Tennessee. H. J. Garber, N. W. Dougherty.

BURNETT, JAMES ROBERT, Associate Professor of Electrical Engineering, Purdue University, W. Lafayette, Indiana. R. P. Siskurd, W. M. Hesselberth.

BURRILL, CLAUDE W., Assistant Professor of Mathematics, New York University, New York, N. Y. H. A. Giddings, G. A. Yanosik.

CASE, PAUL W., Associate Professor of Manufacturing Processes, Purdue University, Lafayette, Ind. H. A. Bolz, R. W. Lindley.

CHAVE, CHARLES T., Asst. Chief Engineer, Stone & Webster Engineering Corp., Boston, Mass. W. F. Ryan, D. H. Feener.

CHRISTENSEN, HARVEY D., Assistant Professor of Mechanical Engineering, Oregon State College, Corvallis, Ore. J. L. Gray, E. C. Willey.

CIPRIANO, WILLIAM, Instructor in Engineering, East Los Angeles Junior College, Los Angeles, Calif. L. W. Holman, C. E. Guse.

CLARK, JOHN R., Associate Profesor of Electrical Engineering, Purdue University, Lafayette, Ind. L. E. Beck, L. A. Kramer.

CLYDE, ARTHUR W., Professor of Agricultural Engineering, Pennsylvania State University, State College, Pa. E. A. Myers, J. H. Moore.

COLBY, MALCOLM Y., Professor and Chairman, Department of Physics, University of Texas, Austin, Tex. W. R. Woolrich, B. E. Short.

COVINGTON, BEVERLY J., Instructor in Civil Engineering, Northwestern University, Evanston, Ill. M. B. Gamet, C. W. Muhlenbruch.

CRAIG, EDWARD J., Assistant Professor of Electrical Engineering, Northeastern Uni-

versity, Boston, Mass. M. W. Essigmann, L. F. Cleveland.

CUMMING, JOHN T., Instructor in Chemistry and Chemical Engineering, Case Institute of Technology, Cleveland, Ohio. T. J. Walsh, W. Van Voorhis.

CURRERI, JOHN R., Associate Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. J. Modrovsky, J. Bartels.

DAVIDS, NORMAN, Professor of Engineering Mechanics, Pennsylvania State University, State College, Pa. J. W. Breneman, G. J. Hasslacher.

DAVIS, JEFFERSON D., JR., Associate Professor of Civil Engineering, Tuskegee Institute, Tuskegee Institute, Ala. W. Allan, W. L. Willig.

DETWILER, VINTON V., Associate Professor of Research, Pennsylvania State University, State College, Pa. A. Addison, C. H. Tindal.

DEXTER, GREGORY M., Consulting Ind. Engineer, Scarsdale, New York. L. E. Grinter, A. B. Bronwell.

DOLANSKY, LADISLAV O., Assistant Professor of Research in Communications, Northeastern University, Boston, Mass. W. C. White, F. R. Henderson.

DOYLE, JOHN R., JR., Assistant Professor of English, The Citadel, Charleston, S. C. J. Anderson, J. C. Key.

DUNK, ALLAN C., Instructor in Mechanical Engineering, Purdue University, Lafayette, Ind. A. S. Hall, Jr., J. B. Lusk.

EASTMAN, R. MERRIAM, Associate Professor of Industrial Engineering, Georgia Institute of Technology, Atlanta, Ga. F. F. Groseclose, W. W. Cox, Jr.

ELESSER, THADDEUS M., 214 Talbot Lab., University of Illinois, Urbana, Ill. W. J. Worley, H. T. Corten.

ESTRIN, JOSEPH, Assistant, Chemical Engineering, Columbia University, New York, N. Y. C. F. Bonilla, T. B. Drew.

FENSKE, MERRELL R., Director, Petroleum Refining Laboratory, Pennsylvania State University, State College, Pa. D. Steryder, G. L. Haller.

FOLTZ, WILLIAM E., Assistant Vice President, New York Telephone Co., New York, New York. C. T. Shrage, D. S. Bridgman.

FOX, RAYMOND RICHARD, Instructor of Civil Engineering, Northwestern Technological Institute, Evanston, Ill. H. P. Hall, C. W. Muhlenbruch.

FREDERICK, MELVIN EDWARD, Patent Lawyer, Pennsylvania State University, State College, Pa. C. H. Tindal, R. A. Hussey.

GALBRAITH, EDWARD DALE, Instructor in Engineering Drawing, University of Toledo, Toledo, Ohio. G. E. Parkratz, J. T. Davey.

GILES, EDWARD STARKEY, Assistant Professor of Electrical Engineering, Clemson, College, Clemson, South Carolina. S. R. Rhodes, M. W. Jones.

GRAY, PAUL GORDON, Assistant Professor of Electrical Engineering, Michigan State College, East Lansing, Mich. R. L. Sweet, C. M. Cooper.

GUTZWILLER, MARTIN JOSEPH, Assistant Professor of Structural Engineering, Purdue University, West Lafayette, Ind. R. B. Wiley, M. B. Scott.

HANSEN, PETER GARDNER, Instructor of Mechanics, Missouri School of Mines, Rolla, Mo. R. A. Schaefer, R. A. Davidson.

HARRINGTON, HAROLD E., Head of Physics, Oklahoma Agricultural and Mechanical College, Stillwater, Okla. A. L. Betts, A. Naeter.

HAUGHTON, KENNETH ELWOOD, Instructor of Engineering Drawing, Iowa State College, Ames, Iowa. J. S. Kising, M. W. Alenfeldt.

HAWTHORNE, EDWARD I., Assistant Professor of Electrical Engineering, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. H. Sohon, J. S. Brainerd.

HELM, M. STANLEY, Professor of Electrical Engineering, University of Illinois, Urbana, Illinois. L. A. Rose, R. J. Martin.

HERMAN, GEORGE J., Assistant Professor of Civil Engineering, Montana State College, Bozeman, Mont. E. W. Shilling, E. R. Dodge.

HEWITT, WILLIAM LEONARD, Assistant Professor of Civil Engineering, Cornell University, Ithaca, N. Y. A. J. McNair, Fred J. Spry.

HILE, HOWARD BURTON, Instructor in Mechanical Engineering, Bucknell University, Lewisburg, Pa. G. A. Irland, W. D. Garman.

HOFFMAN, CLYDE HARRIS, Assistant Professor of Electrical Engineering, University of Notre Dame, South Bend, Ind. H. E. Ellethorn, H. A. Foecke.

HOLMES, JOE BENSON, Manager of Technical Recruiting for Western Region, Gen-

eral Electric Co., Schenectady, N. Y. W. S. Hill, M. M. Boring.

HOOVEN, MORRIS DANIEL, Electrical Engineer, Public Service Electric & Gas Co., Newark, N. J. M. M. Boring, D. S. Bridgman.

HUBER, MATTHEW JOSEPH, Assistant Professor of Civil Engineering, Michigan State College, East Lansing, Mich. R. L. Sweet, C. Cooper.

HYDE, THOMAS BASKERVILLE, Instructor of Civil Engineering, South Dakota School of Mines and Technology, Rapid City, S. D. D. A. Thorson, A. C. Scheer.

JAHN, WALTER H., Senior Personnel Engineer—College Relations, Boeing Airplane Company, Seattle, Wash. V. M. Ganzer, A. A. Soderquist.

JAMES, HENRY A., Instructor of Engineering, San Bernardino Valley College, San Bernardino, Calif. C. M. Duke, E. B. Heath.

JENKS, BARTON L., Assistant Professor of Mechanical Engineering, Pennsylvania State University, State College, Pa. H. L. Dillenbeck, M. S. Gjesdahl.

JENSEN, ERLING N., Associate Professor of Physics, Iowa State College, Ames, Iowa. W. C. Alsmeyer, L. O. Stewart.

JONES, E. ROGER, JR., Instructor in Mechanical Engineering, Louisiana State University, Baton Rouge, La. F. T. Carroll, Jr., John G. Blanche, Jr.

KLOPP, MARK EDWIN, Assistant, Engineering Drawing, The Pennsylvania State University, State College, Pa. H. L. Dillenbeck, M. S. Gjesdahl.

LAWRENCE, ALBERT ARNOLD, Professor of General Statics, U. S. Coast Guard Academy, New London, Conn. E. P. Rivard, J. B. Hoag.

LEW, HENRY G., Associate Professor of Aeronautical Engineering, Pennsylvania State University, State College, Pa. D. J. Peery, J. H. Moore.

LI, SHU-T'IEN, Visiting Professor of Civil Engineering, Rutgers University, Syracuse, N. Y. P. P. Rice, W. B. Snow.

LITTLE, ALTON SCOTT, Assistant Professor of Engineering Drawing and Design, Alabama Polytechnic Institute, Auburn, Ala. J. E. Hannum, L. M. Sahga.

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WOLF, LEONARD, Professor and Head, Architecture and Architectural Engineering, Iowa State College, Ames, Iowa. L. O. Stewart, F. Kerekes.

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ZOBEL, EDWARD CHARLES, Field Engineer, Division of Industrial Services, State College of Washington, Pullman, Washington. L. S. Francis, J. A. Bailey.

775 new members elected last year

ANNUAL MEETING—1955

Pennsylvania State University

State College, Pa.

June 20-24, 1955

Do You Know—

► Dr. George Gullette and his Field Study Group have taken a vigorous hold of the Humanistic-Social Research Project and are visiting colleges and universities in search of outstanding achievements in this area of education. They are seeking evidence of effective organization of subject matter, teaching methods, programs which stimulate interest in these subjects and general excellence of curricular objectives. This material will be reviewed by the Humanistic-Social Research Committee headed by Dr. Edwin Burdell, President of Cooper Union. The Committee will project ahead with their own views and recommendations. A preliminary report of this project is anticipated in June 1955. The project will probably require two years to complete. We will keep you posted on its progress.

► The two Summer Institutes for 1954 proved to be highly successful, judging from the enthusiastic comments of those who attended. The Summer Institute on Solid State Physics in Engineering Education at Carnegie Institute in June included a number of eminent authorities. Approximately 110 persons were registered in this Conference, which lasted about a week. The Summer Institute on Nuclear Science in Engineering Education held at Northwestern University September 7–10 also featured a number of eminent authorities, including Dr. J. C. Slater, Dr. Samuel Glasstone, Dr. Linus Pauling and others who have worked on the broad front of nuclear science.

The heartening feature of both of these Summer Institutes is that the physicists clearly recognized the problem and offered recommendations for solutions which seemed to be both feasible and adequate. In both Summer Institutes, there was strong recommendation that a course in modern physics be included in all engineering curricula. The subject matter of such a course was discussed at considerable length. Several textbooks will soon emerge which treat this subject in a manner suitable for engineering students. In the Solid State Physics Conference, the fundamental scientific concepts necessary to a reasonable comprehension of the electrical, mechanical, magnetic and metallurgical properties of materials was presented.

In nuclear science, considerable attention was devoted to developing logical patterns of presenting material and also to determine how the fundamental concepts might be developed in courses and curricular options. In both the solid state and nuclear fields it seems desirable to establish elective courses for those students who are interested in these fields. While there was some support for an undergraduate curricular option in nuclear engineering, the prevailing opinion seemed to favor developing graduate programs to satisfy this need.

Summaries of both Conferences will be published in forthcoming issues of the JOURNAL. The complete Proceedings of both Summer Institutes will be available and will be announced in the JOURNAL. The ASEE owes a deep debt of gratitude to the National Science Foundation for its financial support, to the University of Illinois and Columbia University which sponsored the original planning conferences of leading authorities in this field and to Carnegie Institute and Northwestern University for their part in the program.

► At long last the Teaching Aids Manual appears about to emerge. Several thousand teaching aids have been reviewed

by the committees and evaluated for instructional purposes. The Bulletin will give fairly specific information not only on the details of the teaching aids and where they can be obtained, but also the instructional purpose and level at which they might be used. An announcement in the next issue of the JOURNAL will give details of its availability. Watch for it.

► The Graduate Studies Division of the ASEE has proposed that a complete investigation be made of the curricular goals and objectives of graduate study. This proposal was favorably received by the General Council and an ad hoc committee has been appointed to draw up a specific program. The membership of this ad hoc committee includes persons who have been active in the Graduate Studies Division and the Committee on Evaluation of Engineering Education.

► The Committee on Evaluation of Engineering Education plans to meet at the time of the Land Grant College Association Meeting in November to discuss revisions in the Interim Report. There seems to be need for a substantial strengthening of the portions of the report dealing with the humanistic-social portion of the curriculum as well as that dealing with graduate study. A Final Report will be prepared and presented at the Annual Meeting in June.

► Some concern has been expressed over the need for coordinating the individual projects which the Society is currently undertaking. These include the projects on Evaluation of Engineering Education, the Graduate Studies and the Humanistic-Social Research Program. The Executive Board has expressed the view that these should proceed as independent projects with overlapping membership on the various committees and that if coordination is necessary, a coordinating committee can be appointed at some future time to resolve any conflicts in the viewpoints. Ultimately, all of these reports might be published in a single volume.

► The ECRC will again publish its Directory and Review of Current Research this year. It is also planning to publish a book on Creativity in Research, this being a compilation of many interesting papers presented at various ECRC meetings on the subject.

► The ASEE was represented at the EUSEC Conference on Engineering and Education in Switzerland by our Past President, Dean L. E. Grinter. Other U. S. delegates included Dean Thorndike Saville and Colonel L. F. Grant. Considerable interest was expressed in the ASEE Interim Report of the Committee on Evaluation of Engineering Education at this conference. The U. S. delegation was sponsored by ECPD.

► The ASEE was represented at UPADI, the Pan American Conference on Engineering and Education, by Dean W. A. Lewis and Dr. Ralph Morgen.

► May we call your attention to the fact that copies of the Interim Report of the Committee on Evaluation of Engineering Education are available at ASEE Headquarters. The price is 20 cents per copy or 12 cents per copy in lots of 100 or more. Over 8,000 copies have been sold thus far.

► To all those who made the Annual Meeting last year such an outstanding success, we owe our deep appreciation. Dean Everitt and Professor Lisle Rose at the University of Illinois, together with their efficient local committees, helped to make this one of the most memorable events in the history of ASEE. The list of persons who contributed to programing the outstanding conferences of the Councils, Divisions and Committees would be too long to name here. However, those who attended have eagerly testified to the outstanding achievement of this Annual Meeting.

(Continued on page 199)

The ECPD Accreditation Program*

By H. L. Hazen

Chairman, Region II Education Committee, Engineers' Council for Professional Development

A sudden upsurge in awareness of accreditation and of questions about its nature and modes of operation has recently occurred, following the circulation of a preliminary draft report by the ASEE Committee on Evaluation of Engineering Education a few months ago that included some material on accreditation of undergraduate engineering curricula. This accreditation activity does affect in a substantial way the well-being of many engineering schools; hence the increased awareness and interest are indeed fortunate. However, detailed information concerning the entire accreditation activity has not been readily available in published form.[1] It is the purpose of this paper to describe the operations of the ECPD accreditation process, the nature of its standards, and the character of the problems that are regarded as most significant in its operation.

Beginning in 1932, the Engineers' Council for Professional Development undertook to evolve a program of accreditation for undergraduate engineering curricula which led to the first publication of an accredited list in 1936. This in some ways paralleled the earlier program of the American Institute of Chemical Engineers, now integrally associated with the ECPD program. Heretofore ECPD accreditation has attracted relatively little attention except among those actively associated with it and among institutions that have to a greater or lesser degree fallen short of full approval.

The official statement of principles of ECPD accreditation appears each year in the annual report of the Engineers' Council for Professional Development, which can be obtained for a small fee from the ECPD headquarters at 29 West 39th Street, New York.

In the early thirties the movement toward state registration of engineers was in a vigorous process of development. Each state board of registration needed a list of schools whose engineering curricula were judged to provide adequate educational preparation for prospective registrants. It quickly became apparent to the National Council of State Boards of Engineering Examiners that a national list and not 48 separate state lists was essential to avoid serious complication. The National Council therefore appealed to the founder engineering societies for help in establishing a master list. Any state, of course, could modify such a list for its own use, but a national list would be at least an important starting point. The Engineers' Council for Professional Development persuaded the late Dr. Karl T. Compton, then recently made president of Massachusetts Institute of Technology, to head a committee to establish appropriate accreditation procedures.

* Presented at the Annual Meeting of ASEE, University of Illinois, Urbana, Ill., June 15, 1954.

[1] For a recent brief statement including the historical development, see N. W. Dougherty, "Accreditation of Engineering Curricula," *Jour. Elec. Eng.*, Vol. 44, No. 5, Jan. 1954, pp. 290–93.

This original ECPD Committee on Engineering Schools (changed October 21, 1950 to Education Committee) included a representative from each of the then seven constituent societies of ECPD. There were seven committee members, and the country was divided into seven regions, each member serving as chairman of one regional committee for undergraduate engineering curricula.

The principles of operation formulated by this original committee and approved by ECPD proved sufficiently sound to require relatively little change. These principles as stated are broad rather than specific in character. They purposely omit quantitative standards for determining acceptability. The absence of definite specific standards has been criticized from time to time, but thus far, in the judgment of those who over the years have been most responsibly concerned with the activity, this absence is an important strength in the ECPD accreditation activity.

Present Organization and Operation

With this sketch of historical development of the ECPD accreditation program as a background, we turn to its present organization and operation.

The Engineers' Council for Professional Development is now comprised of official representatives of the eight following professional organizations: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, The Engineering Institute of Canada, American Society for Engineering Education, American Institute of Chemical Engineers, National Council of State Boards of Engineering Examiners. Its activities and actions therefore have the status in the engineering profession provided by these constituent organizations.

The list of accredited undergraduate engineering curricula is published each year in the ECPD Annual Report. This list results from actions taken by ECPD upon the recommendations of its Education Committee.

The Education Committee is charged with the working responsibility for organizing and scheduling inspections of individual institutions, considering the reports of inspection committees, and preparing recommendations for final actions by ECPD. Membership on the Education Committee includes its general chairman, a secretary, a chairman and vice chairman for each of seven regions into which the country is divided, such members at large as the Council may appoint (one at present), and a representative of the Engineering Institute of Canada, a total of 18 persons.

The regional vice chairman are new this year. The Education Committee has repeatedly felt the need of having counsel at its meetings from a member of each institutional visiting committee. By having a vice chairman as well as a chairman for each region, it becomes practicable for one or the other to serve as a working member of each institutional inspection committee.

Briefly the operations are as follows. Early in each academic year the regional chairman and vice chairman review the status of institutions in their territory, prepare a list of those whose existing term of accreditation for one or more curricula terminate during that academic year, and check this list with the office of the Education Committee chairman. Inasmuch as ECPD examines curricula only on invitation by an institution, such an invitation is normally forthcoming, either on the initiative of the institution or upon inquiry by the regional chairman. Upon receipt of such invitation, the regional chairman requests the general chairman to send the appropriate bill and questionnaire forms. Subsequently an inspection committee is selected by the regional chairman from the list of constituent society members approved by the respective societies. The Annual Report of ECPD contains this

list. Inspection committees often include persons from adjacent regions where this offers the advantages of availability, transportation, expense or inter-regional comparisons, or in special cases other persons approved by the appropriate professional society.

While the regional chairman or vice chairman is expected in the normal case to be a member of a visiting team, and may be the chairman of this team, he may select another member as chairman in order to distribute the not inconsiderable work load; and perhaps more important, to avoid undue influence of any one person in the preparation of the final reports and recommendations of the inspection committee.

The inspection committee chairman works closely with the representative of the institution, usually the Dean of Engineering, in planning the actual visit. At a mutually convenient time, influenced by the period required for the preparation of the answers to the questionnaire and the convenience of the institution and inspection team members, the team visits the institution. In most cases such a visit requires two days. In recent years the undeniable pressures on almost all who were qualified to serve on inspection teams has tended to result in a shorter inspection time of one day and sometimes a short day. Education Committee experience shows very clearly, however, that the better part of two days is a minimum requirement for adequate on-the-spot data gathering, and this is now required except in special cases. This two days is apart from the preliminary study of catalogue and questionnaire material and the time required for the preparation of the report. Thus each inspector must expect to contribute a minimum of about four days for each institution that he visits as an inspector.

Following as promptly as possible after the actual visit, each inspector prepares his report on the particular engineering curriculum and one or more supporting departments to which he is assigned by the visiting committee chairman, and submits his report to this chairman. The visiting committee chairman then prepares a summary report (in addition to his own individual department report), including the recommendations for action upon which he and his committee have agreed at a final conference at the institution, confirmed or modified by subsequent correspondence. This report goes to the general chairman of the Education Committee.

Confidential Document

As a matter of ECPD policy, this final visiting committee report, including the chairman's summary and the individual inspectors' reports, is a confidential document available only to the members of the Education Committee and the ECPD Council.

The Education Committee meets in June, usually in connection with the annual meeting of ASEE, and again in October just prior to the meeting of ECPD. Prior to the June meeting both the regional chairman and vice chairman will have reviewed thoroughly all of the reports on inspections made in their region during the academic year just ending, and will have prepared a tabular summary for the use of the Education Committeee in its deliberations. At this meeting the results of all institutional visits are considered at length. This, of course, is where the real work of deciding actions is mainly carried out. As an aside, it may be remarked that these are strenuous sessions. The committee takes its responsibilities seriously (as do all participants in this entire program) and any observation or argument that appears to have an element of pro or con bias is promptly challenged. One cannot claim infallibility for the results of such deliberations, but I believe that I have the support of the entire committee—by temperament and by profession independent thinkers—in the claim that truly sincere, earnest effort without stint is applied to

these discussions in the effort to derive sound, objective conclusions.

The second meeting in October is similar and considers cases for which final reports were not available in June. Each of these meetings usually requires the better part of two days, including some time devoted to questions of operation and policy. Recently a third meeting has been called in mid-winter to consider policy matters.

At the annual meeting of ECPD held in September or October the chairman of the Education Committee presents his report to a closed, executive session of the Council. The official Council action is promptly transmitted to each institution concerned, together with a statement in summary form of the principle observations of the inspection committee. The annual report of ECPD, issued following the annual meeting, contains the up-to-date list of accredited curricula.

The receipt by an institution of the official notice and statement is often not the end of the operation. In fact, much constructive work is accomplished subsequently, as discussed later in this paper.

Having thus disposed of the elementary mechanics of the accreditation operation, let us look at some of the aspects of the operation that experience indicates are significant. We may as well tackle one of the more difficult aspects first.

What does ECPD require as evidence of an acceptable standard for accreditation? Basically the answer is the combined judgments of the visiting committee, the Education Committee, and the ECPD Council successively exercised. Many will say, and do say, that ECPD should have a much more definite and explicit measuring stick, that the judgment of a group of men is altogether too vague and illusive a standard by which to appraise a major activity constituting the lifework of tens or hundreds of individuals. The use of definite, quantitative indices with an explicit statement of corresponding, acceptable levels of these indices is urged.

Naturally this subject has been given the most serious and extended consideration, both at the time of the inauguration of the ECPD accreditation program and more or less continuously subsequently. The conclusion uniformly reached by those responsible for this operation is that engineering education, in essence a subtle and complex operation, depends basically for its quality upon the qualities of faculty, administration, and students. One can, and some organizations do, attempt to apply a quantitative and definite measure to the qualities and performance of people individually and collectively in an organization as a measure of quality or merit. In the judgment, however, of those who have looked at this question most searchingly in behalf of ECPD, it has appeared that the combined judgment of several highly respected leaders of the profession can appraise the essential educational experience provided by an institution far better than the most complete and complex type of scoring.

Quantitative Criteria of Acceptability

It may be remarked in this connection that some accrediting agencies—and there are many with whom college and university presidents have to contend—do have quantitative criteria of acceptability. Recently a righteous revolt of college presidents against the cumulative impact of all agencies claiming accreditational jurisdiction has expressed itself in the formation of a National Commission on Accrediting. It is perhaps worthy of note that ECPD is included among those agencies whose over-all activity has been least criticized by NCA, whereas some of the agencies considered the least successful and sound are those having explicitly stated quantitative standards of acceptability.[1]

[1] Considerable information concerning accreditating agencies in the United States and the lists they have prepared is given in Bulletin 1952, No. 3, "Accredited Higher Institutions"—Theresa Birch Wilkins, published by the Office of Education of the Fed-

This is not to say that ECPD does not use quantitative measures and apply quantitative criteria. Can you imagine any group of engineers missing any reasonable, or even unreasonable opportunity to apply numbers to one of their activities? No, you can rest assured that in this ECPD operation the engineers and engineering educators do ask for and talk in terms of numbers, budget, student, faculty, library, salary, teaching load, space, curricular composition and emphasis. All these and many more matters are examined in quantitative terms. But it becomes abundantly clear to anyone concerned with this evaluation operation that there are less concrete and tangible elements involved that have an importance and significance far beyond those capable of quantitative measurement, although they vary in a manner that is often unique and peculiar to a given institution. Hence, to let supposedly objective, quantitative standards weigh heavily in one's judgment at the expense of adequate emphasis on these more elusive qualities would be to miss some of the really important criteria for accreditation.

We who have had some experience in the operation realize all too well that human judgment is fallible; that inspections are less than complete and exhaustive; and that different individuals necessarily make somewhat different judgments on a given question. On the other hand, it is seldom that a group of inspectors drawn from different professional fields, different organizations (including both education and industry) and of widely varied experiences, will differ significantly in their appraisal of a given institution. Very seldom is there important disagreement among the members of a visiting committee as to the nature and quality of the operation observed. The primary question in cases that are obviously marginal is whether the overall educational opportunity, including strengths and weaknesses, good features and bad is adequate to prepare the engineering student to develop into a responsible, competent engineer.

With this brief statement concerning the ultimate nature of ECPD standards, let us take a brief look at the kind of thinking that goes on in the minds of members of the visiting committee, of the Education Committee, and of the Council of ECPD. What is regarded as important; what are some of the typical questions that arise; what are some of the characteristic strengths and weaknesses that occur time and again in institution after institution? If I can convey something of the underlying quality and character of the ECPD operation at the working level, by spot samples, I am sure that any one of you will be able to supply rather accurately the many, many details that are omitted from my description.

When we attempt to appraise a curriculum, or group of curricula, at a given institution, we recognize that the quality of the faculty is the basic, all-important determinant of quality for the school. This is also the most hazardous and difficult quality to appraise. Second only to faculty in importance is the kind of support given to the faculty by the institutional administration. Over the long term, of course, administrative policy as expressed in the selection and support of faculty is what determines the quality of an institution. Those associated with ECPD accreditation realize all too well and have had brought home to them forcefully in concrete cases the hazards of standing in judgment on one's fellows. But this is the important issue, and we may as well recognize the role to which we are inevitably assigned when we undertake such an operation as determining acceptability of an institution for ECPD listing.

In thus stressing the importance of faculty relative to other considerations,

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eral Security Agency, and for sale by the Superintendent of Documents, U. S. Gov't Printing Office, Washington, 25, D. C. Price 35 cents.

I am not wilfully diverting attention from the actual curriculum, from the kind and quality of subjects which are taught to the students or to which they are exposed, the laboratory facilities, the library, the academic standards as evidenced by samples of students' actual work in home problems, examinations, laboratory reports, essays, etc., or any of a number of other components that go to make up the educational opportunity offered and the quality of response required from the students. All these are of course carefully examined by a visiting committee. But I am recognizing that all of these various opportunities offered by a faculty to the students are simply an expression of the character of the faculty.

What is Meant by Good Faculty

Now comes the all-important question, what do we mean by good faculty. Before answering this we have to ask ourselves the question, what do we wish our students to learn. Do we wish them to be merely competent practitioners of today's technology, or do we wish them to achieve that quality of understanding of science, engineering science and human affairs that can deal confidently with the new problems on which they will have to exercise responsibility five, ten and twenty-five years hence? The answer to this question is all-important in determining the standards by which we appraise faculty. ECPD takes the view that the latter ideal is the one that it seeks to recognize and promote, but that as yet it must regard a well done program of the former sort as meeting minimum standards.

What do we like to see in a faculty member? First and foremost, he must deeply enjoy seeing and helping young people to grow and develop. We like to see in him a substantial element of genuine scholarliness, the insatiable curiosity to learn, to acquire deep and fundamental understanding. We want to see him convey this sense of scholarly curiosity and insistence upon deep understanding to his students. We like very much to see in a faculty member evidences of individual and independent thinking. This may express itself in a research program, in engineering practice of a responsible and non-routine character, or in consulting work that is professionally challenging. Some participation in a graduate program where the creative spirit is alive contributes strongly to intellectual vigor. The mere keeping actively abreast of some phase of his field and continually working the ideas underlying new developments into his undergraduate teaching program is some evidence of vitality and continued growth in a faculty member. Stated negatively, repetitious teaching of a textbook, even though competently done in itself, seldom presents to the student the challenge of ideas not yet understood or of problems not yet solved. The professor who himself is at grips with some unsolved problem as a part of his professional activity, can and does usually bring to his students a spirit of inquiry, a stimulation to tackle new ideas, and urge to question deeper into partially understood phenomena.

In these days of increasing sophistication of engineering, uneasy deans and department heads often ask whether a doctoral degree is a firm requirement for the acceptability of a new faculty member. The answer is a "No, but. . . ." The requirements for the Doctor's degree overlap to some extent the requirements for a good faculty member. The letters Ph.D. after a goodly fraction of the faculty names in the catalogue are an excellent show piece for a college dean or president. They are, however, no intrinsic guarantee of quality. Educational opportunities and incentives of the present day are such that many, indeed most young people who are qualified to become important faculty members ten or twenty years hence are likely to be working toward the Doctorate or to have it. If a young man on the faculty or instructing staff does not have, or is not working for a Doctorate, we ask: "Why

not, and does this indicate a deficiency in some important qualities for a future faculty member?" A committee can be persuaded with good evidence that a man without a Doctorate is an excellent man. It would be negligent if it accepted the Doctorate alone as a sufficient demonstration of quality as a teacher and a scholar.

An important collective quality in a faculty is the evidence of good team work, of congenial and easy working relations among them, of a sense of common purpose and good communications with the administration. Just as children often bear serious scars from a broken home, so students feel unhealthy effects from a faculty torn by schisms and petty strife. Although we seldom see such conflicts in an engineering faculty, high collective morale cannot be taken for granted. On the other hand, even the best of teamwork cannot replace notable individual performance and non-routine individual productivity. Good teamwork can accompany congenial mediocrity which concerns itself with achieving smoothly-operating routine and is completely lacking in stimulating ideas.

One of the most difficult problems faced by a visiting committee, and subsequently the Education Committee, is how to appraise the school whose faculty are routinely competent, who are doing an exceedingly conscientious and devoted job, often under serious financial handicaps, whose students are obtaining thorough drill in elementary engineering science and its applications, but who show little evidence of professional thinking or activity beyond the confines of routinely taught undergraduate subjects. They obviously rate an A on devotion, thoroughness, and subject matter adequacy within a restricted domain, but rate D or E or Absent on nearly all elements expressing the forward march of the profession and field. Do they pass or don't they? This is a tough question. For many students and many jobs using engineering graduates such a training is apparently adequate. In its draft-report suggestion of a "professional-general" curriculum the ASEE Committee on Evaluation was attempting to devise an appropriate scheme for recognizing good programs of this sort, but also recognizing that they are quite distinct in kind and objectives from those of more scientific and research-oriented character. The fairly routine curriculum might well meet minimum acceptable though obviously not high standards for professional-general objectives, even though it neither is nor is intended to be research-oriented.

Please don't misunderstand me. This doesn't mean that the professional-general curriculum may not yield future corporation presidents or general managers or indeed research directors.

In looking at a faculty the visiting committee takes quite seriously the institution's salary scale, bearing in mind local living costs and requirements. Here is often a problem of the first order. Many institutions, especially some of the worthy small private colleges have not, despite great efforts on the part of their presidents, been able to build up their assets nearly as fast as the inflation of the last decade and a half has torn them down. The fact that such institutions retain any faculty, much less a faculty as loyal and surely dedicated as they have, is indeed a tribute to the reality of human ideals. But able, new young people of the quality to compete freely in today's market, though willing to make substantial sacrifices for teaching as compared with industry, cannot in fairness to themselves and their families accept the degree of sacrifice imposed by the salary levels in too many of the small colleges we cherish. This is a truly tragic situation.

The present quality of faculty and the outlook for the future raise serious questions for a visiting committee. With the profession calling through ECPD for a raising of minimum standards of acceptability of engineering curricula, what is the right answer in such a case? This

is the kind of question that tries the souls of the Education Committee.

Administrative Organization

Turning now to some of the other matters at which a visiting committee looks, it asks questions about the formal and the actual administrative organization. While it expects no single pattern and regards men as clearly more important than formal organization, it does expect evidence of sound educational leadership, and of an administrative mechanism that permits this leadership to be effective in cooperation with its faculty. Educational institutions often appear to lack such crucial tests as dividend performance or stockholders meetings to force them to face up to uncomfortable issues, with the result that administrative anomalies, wrong in theory and bad in practice are sometimes tolerated, to the obvious detriment of the quality of the operation. ECPD has no fixed standards of acceptability other than that the administration should be reasonably effective in practice.

On another subject, housing and facilities, the ideas are rather simple. Everyone enjoys seeing fine housing and excellent laboratory facilities. However, the quality of the facilities and the quality of work that is done in them do not necessarily have a very high correlation. The applicability of this statement is not limited to educational institutions. A visiting committee is likely to object strenuously, for example, to a Mechanical Engineering Department whose students have no access to any working laboratory in Heat or Materials. A few engines, pumps, and an old turbine that show no evidence of adaptation for even elementary meaningful measurements leave a committee unpersuaded. If, on the other hand, with mediocre equipment one or two professors have developed ingenious means whereby students can learn important principles in laboratory experiments, the committee is likely to commend the Mechanical Engineering Department but to call the administration to task for inadequate support of faculty and students.

Then, of course, there is the case, not too common, of fine equipment in a new building, shiny and unspotted, with no evidence that anyone has ever drilled a new hole or changed a single screw in order to permit a new or better measurement or to alter a characteristic. The presumption will bear investigation that the students get little understanding of what goes on inside the prettily painted housings, and that the faculty are not much better off. This kind of display is also less than impressive.

In a positive sense, a committee is happy to see a laboratory in which it is obvious that faculty and students work hard to gain an understanding of the underlying principles of operation, and the deviations from simple theory that practical design and other limitations impose. If the equipment is of the "boughten-ready-made" variety, the sales representative might shudder to see the state of the finish and the number of less-than-aesthetic appendages that his equipment has acquired. Next to it is a monstrosity similarly bedecked that the professor persuaded the company for which he does consulting to place in the laboratory on indefinite loan at the end of an experimental job. Both of these pieces of equipment and others like them throughout the laboratory suggest intellectual ferment and search for understanding on the part of both students and faculty. Student laboratory project reports and theses deriving from this laboratory as well as the professor's account of the new ideas his students are exploring confirm these suggestions as fact. Here a visiting committee can become enthusiastic.

On still another subject, the committee looks at the curriculum, its level and content. Is it reasonably proportioned as between sciences, engineering sciences, applications, and general education? Are the entering students sufficiently well prepared so that the sciences and the engineering sciences can be and are based

upon a reasonable grasp of the calculus, or better still, elementary differential equations? Is the Physics taught with or without the calculus? Does the Mechanics make any serious entry into Dynamics, or is it limited largely to Statics plus the most elementary Dynamics? Does the Electrical Engineering for non-electricals recognize the implications of the vacuum tube, not to say the transistor, and the dominant part it plays in measurements techniques in recent years in all scientific fields? Does the strength of materials or applied elasticity recognize seriously the phenomena of plastic flow or of fatigue? Has the structures sequence taken into account the implications of the Tacoma Bridge failure?

Broad Horizon and Scientific Depth

Has the engineering faculty recognized that the engineer serves society not by technical engineering alone but as a citizen, as a cultured member of the community and that therefore his education calls for at least a reasonable minimum exposure to the kind of ideas that are found in literature, in history, philosophy, the graphic arts, economics, government, international relations? It not infrequently happens that the curriculum in which it is claimed time is simply not available for general education is burdened by a supercargo of engineering practice, emphasis on manual skills and technical specialties which the engineering faculty has not yet had the insight or courage to throw overboard in favor of a broader horizon for their students and greater scientific depth in their own field.

In the details of individual subjects, the visitor likes to see in the samples of student work—home problems, examinations, laboratory reports, project papers, etc.,—evidences of the student being forced occasionally to leave the beaten track and develop some of his own ideas. Standard exercises in class and laboratory have their place as a means of drill on elementary principles, but the problem that departs from the beaten track, that reflects a pertinent but unusual application of a principle encountered in the course of a professor's consulting work or research; the problem in laboratory or seminar course that requires a student to explore and develop an understanding in an unfamiliar field; these are all indicators of cerebration in the professors and probably in the students. These are healthy signs of good educational experience. Also there is no substitute for high standards of student performance.

The inspection committee is always concerned about the presence in the curriculum of any appreciable number of professional subjects or courses that are primarily descriptive and qualitative rather than analytical and quantitative in their essential character. The competent professor rather regularly works in, quite incidentally, many of the qualitative and descriptive aspects of a field while tackling the more fundamental and difficult, scientific and quantitative aspects. It is, of course, the understanding of the inner principles of operation and fundamental theory that distinguishes the professional engineer from the technician, who is expected to be more skillful than the engineer in the practical techniques of daily operation of involved technical equipment.

There are some other aspects of the general picture that inspection committees and the Education Committee encounter in their consideration of curricula offered for inspection, concerning which comment is appropriate. An institution head, in response to criticism of apparent weaknesses in program or faculty, often replies that their students receive many offers of employment, that they seem to do well in practice, and that therefore their education at the institution must have been less deficient than ECPD has indicated.

The facts of student performance after college in general have to be taken into account. As one who has had considerable association with graduate school activity, I must admit that in professional promise at the graduate school level the outstanding man from a little-known

school, given time to repair gaps in preparation and opportunity, is likely to far outstrip a reasonably good man from a reputedly strong institution. The latter will have, of course, more immediate facility in elementary technical operations. The outstanding man from the relatively weak school may have to shore up considerably his undergraduate foundation before he tackles full scale graduate work, but he will subsequently outrank his intrinsicly less able associate with better preparation. In other words, it is pretty hard for a poor school to spoil a good man. Conversely, the best school cannot make a good product out of poor material; it can merely encourage, inspire, and develop good material. All experienced industrial employers as well as graduate schools are thoroughly aware of these facts.

Appraisal of an engineering school is therefore denied any easy yardstick for measuring the school through determining the performance of its graduates. Twenty-five years from graduation a survey of graduates' accomplishments may show a significant pattern but this has little relevance to the current status. We are therefore left to depend largely on a basically subjective standard of judgment of men recognized as competent in their profession as to what constitutes an acceptable minimum of educational experience in preparation for engineering.

Problems Implicit in the Accreditation Process

Another observation I believe is very important in looking at this accreditation picture broadly. A difficult and trying experience occurs, of course, as a sequel of failure to accredit or of a less-than-maximum-term accreditation, and of the receipt by the president of the accompanying statement of particulars as to strength and weaknesses. Not one of us will take such a reflection on the quality of his institution lying down. The most natural human instinct is to rise immediately in self-defense. One immediately searches, often successfully, for imperfections in the findings of an inspection committee that cannot take time to do a truly exhaustive study. Unhappiness at a less-than-favorable report is not reduced by the normally justified conviction that the institution and its faculty are conscientiously and earnestly putting forth their very best efforts, often under serious financial limitations. Their spirit, enterprise and wholehearted devotion to their endeavors has almost universally resulted in a loyal and devoted group of alumni, staunch supporters among the local industries, and a civic pride in the operations of the institution that are hard to square with a less than flattering ECPD action. Yet as measured against the standard that men respected in the profession consider necessary to prepare engineers adequately to face important future problems, this institution and its work are simply falling short. Every one of us who has had occasion to tell a subordinate or employee of his shortcomings is quite cognizant of the problems of communication under these circumstances. There are equally difficult communication problems when ECPD reports unfavorably to an institutional president. Psychologically he cannot be expected to have an immediate full understanding of this report, despite the best will in the world. The natural reaction is that an injustice has been done, and for this no one can blame him. Here then is another not-so-trivial problem implicit in the accreditation process.

Following these initial defensive reactions, however, there is likely to be a very constructive phase in which an institution decides to take a very serious look at itself, often with the help of other educators and industrialists interested in education. Not infrequently it happens that Education Committee or Regional Committee members are asked for their specific suggestions and advice. While some general suggestions may be appropriate, the necessary response here is that the role of counsel and jury must in the nature of things be kept separate and independent, else too small a group exerts

too wide an influence. It has to be emphasized, and this is a point that is not too readily understood by many, especially those who are in umbrage on accreditation, that there is no one set of conditions to be satisfied in order to achieve accreditation, that there are many ways and patterns in which an entirely acceptable, and indeed commendable, program may be achieved. It is at this point that the advocates of definite, quantitative criteria appear most prominently. The questions are asked; in what specific ways are we deficient, what are the standards that we must meet in order to become accredited? If you don't tell us what these minimum standards are specifically, how can you expect us to meet them? It sometimes takes a bit of exposition and education to convey the ideas that are regarded by ECPD as important measures of quality. The key to such a situation is usually the appointment of some new person in a key post, a person who by temperament, interest and aptitude understands and is convinced of the importance, indeed the essentiality of some of the qualities that we have discussed in this paper. Once this type of leadership is present, and it is given support by the president and trustees, matters begin to improve, often very rapidly.

Conclusion

In spite of its serious and seemingly almost insoluble problems, this work is exceedingly stimulating and interesting. It is carried on without fee or honorarium to anyone, actual expenses only of participants being reimbursed by ECPD. Within the constraints imposed by other commitments, services on inspection committees are given generously by the individuals, their educational institutions, and their industrial employers. Rarely indeed does one sense that the degree of responsibility felt under this voluntary arrangement is one whit less than it would be under a generous consulting contract for services.

Suggestions for improvement are welcomed, for those most deeply involved are well aware that ECPD accreditation like any other human institution falls substantially short of perfection. Yet it must be apparent on second thought that the obvious suggestions, and most of those less obvious, are normally hardy perennials. Significant steps forward are likely to come from those who have been actively involved in one way or another, and who are therefore familiar with the actual problems of operation. As in all human institutions, the greatest opportunity for improvement lies in the increase in understanding, ability, and wisdom of those doing the work.

What is the value of accreditation and what is its future? It has supplied the engineering profession with a list of curricula meeting certain standards. This list has been used by State Boards of Registration and other agencies. Apparently being on this list carries significant prestige value, especially for lesser known schools, judging by the efforts they make to qualify. Many cases could be cited in which ECPD action has resulted in substantially raised standards. For the better known schools evaluation for accreditation offers objective appraisal from without and a report that may challenge complacency.

As to the future of accrediting, there continues active but deliberate thinking, especially associated with NCA, that will undoubtedly lead to further evolution. The underlying needs and purposes of the ECPD program, and the over-all quality of its operation, are quite generally recognized. Further evolution in this program may therefore be expected in the direction of developing cooperation with other agencies and associations of colleges and universities consistent with continued effectiveness of ECPD accrediting in meeting its own necessary objectives.

Another article on this subject, entitled "Relations with Regional Accrediting Associations," will be published in the November, 1954 issue of THE JOURNAL OF ENGINEERING EDUCATION.

Editor

Creativity in Radio

Contributions of Major Edwin H. Armstrong*

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I

My purpose here today is to outline the contributions and to analyze some of the factors which have contributed to the creative genius of one of the great inventors of our time, Edwin Howard Armstrong. He would have been here today to speak for himself were it not for his tragic death some months ago. In discussing Major Armstrong, I may betray a certain amount of hero worship to which I freely confess for he was an heroic figure to all who knew him. In some ways, my speaking for him may give you a better picture than he would have been able to do for himself. Possessed of an innate modesty he probably would have minimized his role and personal contributions to the phenomenal series of inventions which have laid the foundations of modern radio communications. In referring to him I shall use the appellation of Major because he preferred it over others to which he was entitled.

To emphasize the importance of the contributions of Major Armstrong, I shall outline his inventions before going into his life, his times, his education and those personal characteristics which contributed to these successes. The four basic discoveries which represent his most important but by no means only creative contributions are the regenerative circuit, the superregenerative circuit, the superheterodyne receiver, and the broad-band frequency modulation system. These will be taken up in turn.

At the time of the invention of the three-element vacuum tube named the "audion" by Lee De Forest in 1906, radio communication, as we know it today, was launched. In those early days tubes were expensive and scarce and their characteristics none too favorable, so that it was imperative to increase the effectiveness of each individual tube. Setting the then accepted theories aside and embarking on an experimental approach, Major Armstrong was able in 1912 to obtain unheard of sensitivities from a single triode. While commonplace today, the concept of reinforcing a week input signal to the tube by feeding back a small portion of the output signal was revolutionary. He not only observed this phenomenon but was perceptive enough to realize its importance as an invention which he disclosed on January 31, 1913, and finally patented in 1914. The regenerative feedback circuit made possible communications across and between continents with a minimum of tubes.

Shortly after the initial disclosure of the regenerative principle for use as a sensitive receiving detector, Major Armstrong discovered that by increasing the amount of feedback it was possible to cause self-oscillations in the circuit. The tremendous importance of this property was quickly evaluated by Armstrong because a technique for producing oscillation by this means would replace the older spark or arc transmitters then in use. He filed a separate patent applica-

* Presented at the Annual Meeting of ASEE, University of Illinois, June 16, 1954.

tion for this circuit, a factor which later cost him heavily in patent litigation. De Forest was able to win an interference suit in 1924 which resulted in the issuance of patents to himself for the oscillating audion and regenerative circuit and the rejection of Armstrong's application for a patent on the oscillator circuit. Ultimately, as late as 1934 and after long and expensive litigation, the Supreme Court upheld the contention that De Forest was the inventor of the regenerative circuit and oscillator although the engineering and scientific societies, including the American Institute of Electrical Engineers, the Institute of Radio Engineers, and the Franklin Institute, generally discredited this decision by awarding medals and honors to Armstrong for his inventions including the regenerative circuit.

These brief references to Armstrong's patent litigation are cited not so much for their importance to the purpose at hand but to emphasize early in this talk a facet of his character which led him to fight tenaciously for what he considered to be right. This he did even when it cost him heavily and when he might have benefited financially by accepting an adverse decision. His lifetime will show many other instances of this characteristic.

Superheterodyne Reception

Chronologically, the second of his great discoveries was the system of superheterodyne reception. The first in the sequence of events leading to this invention was, the heterodyne principle which he studied experimentally and presented in his outstanding paper before the Institute of Radio Engineers in 1916. This paper laid the foundations for the future by rationally explaining the phenomenon of beating two high frequency inaudible signals to obtain an audible difference frequency signal. During World War I, the principle of superheterodyne reception was synthesized as a result of speculation on his part that attacking German bombers could be fired upon more accurately if they could be located by picking up the radiation from their ignition systems. The frequency content of this radiation was very high for those days and could not be picked up by then existing methods. The whole concept suddenly occurred to Armstrong that if he could reduce the frequency of the short waves to a value more manageable for amplification, receivers of much higher sensitivity could be designed. In retrospect, this seems to be a natural outgrowth of his early studies in the field of heterodyne detection. In his 1916 paper, Armstrong was dealing with the reduction of the frequency of a received signal from a high inaudible frequency, say 100 kilocycles to an audible frequency of, say 1 kilocycle, by beating with a local signal at 99 kilocycles. The principle was extended to take a very high radio frequency, say 10 megacycles and beat it down to an intermediate but inaudible frequency of say 150 kilocycles, amplifying at this frequency and then detecting the audible signal in this amplified signal. This invention was not used for its original purpose in World War I but it did become the basis for practically all radio reception including radar. It is interesting to note that the circle was completed only in World War II when radar detection of enemy aircraft came into its own using, a reception technique invented by Armstrong for the same purpose more than twenty years earlier. It can truly be said that the invention of the superheterodyne receiver represents a superb exhibition of inventive genius where one step logically led to another and a set of unrelated facts were synthesized into a useful device.

Shortly after his return from World War I, Major Armstrong became involved in the first of a series of court suits in defence of his patents. It was while carrying out an experiment at Columbia University to prove convincingly that statements made by opposing counsel were in denial of fundamental truths that he came upon the principle

of superregeneration. While testing a regenerative circuit using a miniature transmitter located across the room without an antenna, he noted strange signals coming in with unbelievable signal strengths. Numerous transmitting stations were identified and their signal strengths were far beyond those observed in previous regenerative receiver tests. Far from ignoring this effect, he tenaciously studied it and finally brought to light a new principle of regeneration. What had happened was that the regenerative detector was being triggered on and off oscillation at an inaudible rate so that on the average, the circuit was being operated at a condition of tremendous gain located near the point of incipient oscillation. It was his ability to recognize that he had found a basic and important new principle that accentuated his genius, for it must have been true that many other experimenters had noted the effect previously. As a matter of fact, Armstrong himself came upon some old notes indicating that he had produced superregeneration in his early experiments many years before but failed to recognize it. This is a lesson that he never forgot and one which made him emphasize his persistence and care in experimentation lest unusual phenomena should go by without being noticed.

Frequency Modulation

Major Armstrong's final important invention was that of static-free frequency modulation reception known as FM. Ever since his early days with Pupin at Columbia, he had dreamed of the day when static, that is natural and man-made electromagnetic disturbances, would be overcome and useful signals could be received clearly and with high fidelity at all times. The basic technique used by Armstrong to solve this problem was to employ a system of modulation in which the intelligence was applied to a carrier signal by varying its frequency. This idea was by no means new, having been considered by numerous authorities in the field and having been discarded as impractical and as having no particular advantage over the current amplitude modulation system (AM).

In particular, expert opinion of the day was that the comparison between FM and AM based on both theory and experiment indicated no particular advantages for FM. This situation would have been enough to discourage any investigator from going much further. However, Major Armstrong had other ideas. He studied some of his concepts developed as far back as 1915 which led him to believe that broad-band, not narrow-band FM was the key to the problem. In view of the fact that the energy of the random noise or disturbances admitted into a circuit is proportional to its bandwidth, his notions seemed completely contrary to accepted concepts. The only trouble was that these concepts, correct as they were, were being applied to only one form of FM and did not reckon with the basic element in the Armstrong system which included the amplitude limiter. This device clipped off all amplitude variations superposed on the signal by unwanted static and permitted only the desired frequency variations containing the intelligence to pass through. The broader the frequency swing of the desired signal, the less significant would be the undesired swings due to noise. It was simply a case of the right theory being applied to the wrong model and again Armstrong proved that he was by far a more precise mathematical thinker even though he did not indulge in the writing of mathematical relationships.

In any case, the broad-band FM system including the all-important amplitude limiter was patented in 1933. This invention made possible the reception of almost completely static-free signals even in the midst of violent thunderstorms in the immediate vicinity, and this was indeed a technological triumph. Accompanying this great advantage was that of high fidelity made possible by the broader bandwidth employed by the sys-

tem. Also, it was possible to prevent interference between adjacent stations since the Armstrong system caused the weaker station to be completely suppressed. By employing higher carrier frequencies he opened up a new large piece of the frequency spectrum to broadcasting. Finally, the cost of construction and operation of FM stations was less than that of AM stations with the same coverage.

Conflict of Interests

However, it was one thing to achieve this tremendous success and still another to bring about its acceptance by the broadcasting industry and the government. The conflict of interests between established organizations, like the Radio Corporation of America, and Major Armstrong had begun in all seriousness. The fight to bring about adoption of this, his greatest invention, consumed so much of Major Armstrong's time and energy that he was diverted from his primary activity of study and experimentation. FM proved to be the last of his great inventions and most of his activities from the issuance of the FM patent to the time of his tragic death were directed to the fight for adoption of FM. His devotion to this task proved to be so intense that his FM fight has often been referred to as his Cause. He was cast in the role of the lone inventor pitted against the array of great corporations that characterize our economy. In this task he was as dogged, as brilliant and as assured as he had ever been in ferreting out an interesting and peculiar phenomenon in the laboratory.

This recital of the most important technical achievements of Major Armstrong is by no means complete. It has been given to bring into focus the magnitude of his creativity and life-long achievement and to provide the framework into which to attempt to fit the human being that was Major Armstrong. The remainder of this discussion will be devoted to an attempt to explain the factors which contributed to his amazing record.

II

Edwin H. Armstrong was born in 1890 and spent much of his youth in the city of Yonkers, which as you probably know lies adjacent to New York City. While not wealthy, his family lived comfortably, his father being United States representative of the Oxford University Press. In view of his father's position it is not surprising that he was an avid reader of books, a factor that influenced the course of his life. That his preferred reading dealt with the lives of such great inventors as Volta, Hertz and Marconi was significant. One of his favorite idols was Faraday whose accomplishments he rivalled in later life. During his teens Armstrong filled his attic room in the Armstrong house in Yonkers with all the paraphernalia of the typical radio ham, including various wireless contraptions such as coherers, interrupters and spark coils of the day. Most of his spare time was spent listening to the dots and dashes of other radio hams in Yonkers and vicinity and occasionally picking up Naval and commercial stations both near and far. By the age of 19 Armstrong was ready to enter college and the maturing of the amateur into the professional had begun. It is important to note than even before entering college he had decided with typical singlemindedness to become an inventor in the field of radio and never to the day of his death did he waver from that objective. This man was no confused uncertain young teenager who had to have someone else make up his mind for him!

In 1909 Armstrong entered Columbia University to study electrical engineering and came under the influence of the great inventor and teacher, Michael Pupin, who was then Professor of Electrical Engineering. It was soon evident that, aided by formal training in electrical engineering, he had developed a knowledge of radio which far exceeded that contained

in the textbooks of the day or, for that matter, of many of his instructors. His outstanding performance in this regard led him to study the performance of the then new and revolutionary De Forest audion while still a college junior. His experimentation resulted, as noted before, in the invention of the regenerative detector in the year 1912.

Scientific Turn of Mind

It is important to observe that a major technical contribution made by Armstrong about this time was not just the regenerative circuit itself which was an invention of first rank but also the explanation of the operation of the triode vacuum tube. Until then, it had been regarded as a trigger device, but Armstrong, with typical clarity and logic showed that its performance could be explained by the use of a characteristic curve and laid the groundwork for the vacuum tube circuit theory of today. This illustrates a scientific turn of mind possessed by very few undergraduate students today.

One might be tempted to conclude that Armstrong was a bookworm or possibly a "lab-worm" who paid little or no attention to other aspects of student life. Nothing could be further from the truth. While in college he rode, somewhat recklessly it is said, the hot-rod of his day—a red Indian motorcycle. He entered the usual freshman-sophomore contests and became a tough competitor on the tennis court. The latter sport was one of his favorites and he played well until he sustained an injury to his shoulder in later life. Nevertheless, despite these recreations, Armstrong never wavered from his primary objective, radio. By the time he was a college senior, Armstrong had a basic invention and the benefit of association with Pupin, a foremost inventor in his own right.

Because of his intense interest in his subject and because laboratory facilities would be available to him, Armstrong accepted an assistantship at Columbia University where he continued his work. His salary was quite low, only $50.00 a month, and I have often heard him relate how he used to have his one meal a day at a small restaurant on Broadway near the University because the proprietor was so foolish as to allow him all the bread he could eat with his meal. Not long after his acceptance of this post at the University, his regenerative patent issued and royalties began to pour in at the rate of about $8000 per year.

One might note here that the excellent guidance he received from Pupin and his associates on the management of his affairs as an independent inventor may have laid the seeds of much unhappiness and frustration in later years. Had he renounced all commercial advantage or financial return as his idol Faraday, his creativity might have been even greater because much of the energy he diverted to court actions and litigation would have been available for scientific work. But such was not to be, and much of Major Armstrong's life was spent in the defence of his rights as he saw them. It is interesting to note, however, Armstrong never relinquished his interest in or association with Columbia University and its freedom of thought and investigation, taking over and holding until his death Pupin's chair in electrical engineering. He was always the serious-minded, thorough, experimental scientist.

World War I found Armstrong in uniform as a captain in the Signal Corps. Whoever was responsible for assignment of personnel at that time should be congratulated for having placed Captain Armstrong in a position where he could help solve the problems of communications from ground to aircraft and many other similar problems in which he was a foremost expert. It was in this service that the inspiration for the superheterodyne receiver came to him. Discharged as a Major, he returned to Columbia to resume his life as a scientist and inventor.

Court Clashes

Once back, Armstrong entered into the first of his many court clashes in defence of his patents. The whole question of the regenerative circuit and oscillator against De Forest came up and during the proceedings, Armstrong was made an offer of $335,000 by Westinghouse Company for his regenerative and superheterodyne patent rights. In the meantime, he returned to his work on static elimination with Pupin and accidentally discovered, as described previously, the principle of superregeneration. Concurrently, he participated in the series of tests in 1921 sponsored by the American Radio Relay League which resulted in the successful communication between the United States and England on so called short wave transmissions at a wavelength of about 200 meters. It is significant to note that his colleague, Paul Godley, who picked up the signal in Scotland, used a superheterodyne receiver. Shortly after these tests his superregenerative patent issued, and by 1922 he negotiated with the Radio Corporation of America who wished to buy the rights. Negotiations were completed resulting in the payment to Armstrong of $200,000 in cash and 60,000 shares of RCA stock. This block of stock, combined with 20,000 additional shares for later services, made Armstrong one of the largest stockholders of the growing company. Financially, Armstrong was a multi-millionaire but this made little or no difference to his devotion to radio and his quest for static-free reception.

As a result of many visits to David Sarnoff's office at RCA, he met and courted Sarnoff's secretary, Miss Mac Innes. During this period he lost no opportunity to impress her with feats that were often quite daring and which reflected a bold and boyish personality. The most memorable of these was his hand-over-hand climb of the 400 foot tower of radio station WJZ. When he reached the top he stopped to pose for photographers. Whether or not this had any significant effect on his courtship is hard to say. At any rate, he and Miss Mac Innes were married in 1923.

Shortly after his marriage, Armstrong resumed his series of experiments at Columbia, which culminated in the invention of wide-band FM in 1932 with the patent issuing a year later. It was the fight for adoption of FM which constituted his most bitter series of disappointments. Armstrong tried to interest RCA in his new invention but for reasons which can only be speculative, but which involved the problems of existing investments, the coming of television and possibly personal relationships, he was rebuffed in a manner which offended Armstrong's sense of fair play. At any rate, it may be said that he declared war on RCA to the extent of turning down in 1940 an offer of 1 million dollars for a royalty-free license. The concurrent fight for broadcasting allocations was carried to the Federal Communications Commission where Armstrong finally obtained the allotment of a band in the 40 megacycle range for FM broadcasting. After the war, despite the fact that 500,000 sets were thereby rendered obsolete, the FCC moved the FM band up to its present 100 Megacycle range. This dealt a hard blow to FM, but still it flourished so that by 1949 there were 600 stations on the air. Throughout this latter period, however, RCA was waging war on Armstrong's patent position and most set makers were not paying royalties to Armstrong but were using the so-called ratio detector based on patents held by RCA. Armstrong claimed that this was an infringement and brought suit. The suit was at the stage of pre-trial hearings at the time of his death.

Armstrong fought the battle for FM with the same tenacity he used when attacking his technical problems. Above all, he was outraged at what he considered unfair treatment by RCA, and this may have affected his better judgment so far as personal advantage was concerned. His wife and his colleagues

would have wished him to retire and enjoy his remaining years surrounded by loyal friends and revered as elder statesman of radio. The fact that he continued his fight was characteristic of the dogged tenacity which was so essential to his success.

III

Let us try now to review the important characteristics which may have contributed to Major Armstrong's creativeness in research. First, and foremost, he possessed a genius and character which was God-given. Placed in exactly the same circumstances, only a very few human beings would have had the capacity to achieve a fraction of what Armstrong accomplished. He was single-minded in his objective in life. He was thorough, very hard-working and indefatigable. When asked how Armstrong managed to achieve what he did, one of his assistants stated that he was willing to spend 23 out of 24 hours of his day concentrating on radio. If ever there was an example which illustrated the cliche that creative research is only slightly inspiration and mostly perspiration, he was it. He would repeat an experiment over and over again with little or no regard of the hour until every peculiar effect was fully explained.

The second important factor in his life was the professional education which he received. While he no doubt benefited greatly from his amateur radio activities before entering college, it was his formal education which matured him professionally. In addition, he came under the influence of a foremost teacher, inventor, and scientist in Professor Pupin who earned the reverence of young Armstrong. By making laboratory facilities available to Armstrong, Pupin greatly furthered his productivity.

The third important factor was the timing of his career. The time was ripe for the exploitation of the vacuum tube. Great research organizations sponsored both by industry and government were not in existence and the individual inventor had a good chance to do significant work. The type of work done by Armstrong as an individual in the early decades of the twentieth century is done now by whole organizations of engineers and scientists. It is correct to state that Armstrong is probably the last as well as possibly the greatest individual American inventor.

Fantastic Capacity To Think In Physical Terms

The fourth factor was Armstrong's fantastic capacity to think in physical terms. It is often said that he was a non-mathematical thinker, but such a statement would have been challenged by Pupin. If by mathematics one means simply the formal writing of symbolic mathematical relationships between quantities, he was indeed non-mathematical. A striking characteristic of his papers is that they are generally devoid of any equations. However, if one means by mathematics the exact science of rigorously following one step of logic with another to describe the whole, not necessarily using symbolism, then Armstrong was a foremost applied mathematician. It has been said that he disdained and distrusted the mathematical approach. However, from personal experience I know that he had the highest regard and respect for those who used the mathematical approach. What he objected to was the use of mathematics for its own sake or the application of erudite mathematics to an incorrect physical model resulting in the prediction of an incorrect performance. He demonstrated this devastatingly with his invention of broadband FM. As an experimenter, Armstrong had the uncanny faculty of observing effects and then assembling them into a logical whole thereby producing a clear concise and correct picture of a particular phenomenon. He demonstrated this over and over again starting with his early description of the performance of the triode, explaining the phenomenon of heterodyne and finally pre-

dicting the effect of broadband FM on noise reduction.

The fifth factor of importance was his ability to inspire loyalty among his colleagues and assistants. Armstrong was recognized by all as an important figure. Yet he retained a modesty and self-effacing character which made all who knew him or worked for him respect and like him. I asked him on at least two occasions to tell me what it was that was responsible for his enormous productivity and success. The question embarrassed him and he evaded a direct answer by reciting certain factual occurrences in his professional life. Never did he play up in any way his personal role. Probably he did not really know exactly what it was that made him the great man he was. His generosity and loyalty towards those whom he felt dealt honestly with him was renowned. At the same time his tenacious opposition to those he felt did not was equally well known.

Youthfulness of Outlook

Lastly, a factor which undoubtedly contributed to Armstrong's productivity was a youthfulness of outlook, a boyish enthusiasm which is hard to define. It was brought out tangibly in a number of his more daring feats such as the memorable climb to the top of the WJZ tower, or his swinging at the top of his Alpine tower in a boatswain's chair to adjust the antenna feed for his FM station. More intangibly, it shone in his eyes when he talked about his work. I shall never forget my last meeting with the Major, some two months before he died. The occasion was dinner at his apartment to which I had been invited to meet a business acquaintance of his who had a research and development proposal which he thought might be of interest to me. The Major was in a good mood. Only occasionally did he show a few flashes of the loneliness which lifelong concentration on his work brought upon him. At the end of a most enjoyable evening, his other guest and I bade him good night in the foyer of his apartment. I clearly remember him as I shook his hand. He was tall, powerfully built, one shoulder drooping slightly, his head bald, smiling his typical crooked smile, and looking a bit tired. But the most striking thing of all was the characteristic twinkle in his eye which belied his age and was like that found in a young man looking forward to another exciting day. Perhaps this was the most important asset of them all.

Major Armstrong died on February 1st of this year. At the time of his death he was in the midst of his greatest battle for FM. Regardless of the rights or wrongs of this or any of his other conflicts, opponents as well as partisans will probably agree that Major Armstrong was the most important creative thinker and inventor of all time in the field of radio and that his passing marks not just the end of the life of a great man but also the end of an era.

Sections and Branches

An Annual Meeting of the **Pacific Northwest Section** was held April 24, 1954 at Oregon State College, Corvallis, Oregon. Section Officers for 1954–55 were elected. These were:

Chairman—M. L. Jackson
Vice Chairman—L. Craine
Secretary—J. T. Norgood.

Some of the topics discussed at this meeting included NSF Sponsored Short Schools, Humanistic-Social Studies, Evaluation of Curricula, Increased Local Section Influence, Accreditation, YET, E.C.-P.D. Meeting and the Meeting of the Committee on Evaluation of Engineering Curricula.

The Triumvirate for Improving and Maintaining Good Teaching*

By R. L. SWEIGERT

Dean of Graduate Division, Georgia Institute of Technology

Before starting on the subject of improving and maintaining good teaching, I would like to raise one question: why is it such a problem to arouse the *active* interest of our college faculties and administrations in the problems of teaching when teaching is our main business? A few of those concerned do have this interest but why should it not extend across the board and involve everyone concerned in higher education. Should not most of our educational activities and expenditures be judged on the basis of their contribution to the educational process?

Before we can take up the matter of improving and maintaining good teaching we need to reach reasonable agreement on the definition of good teaching. I am, therefore, going to present a point of view, backed by statistical evidence, that can form the basis for improving and maintaining good teaching.

There are three direct points of attack on the problem, forming what I have taken the liberty to call, the triumvirate for improving and maintaining good teaching. These are:

1. The training of prospective teachers in the graduate schools.
2. The in-service training of new teachers on the job.
3. The evaluation and recognition of good teaching all along the line.

The first two provide the necessary preparation (now largely left to chance) for those entering the teaching profession and the third provides for maintaining good teaching through evaluation, through a careful study of a teacher's effectiveness each year, and through provision for proper recognition of that effectiveness. I believe everyone will become more vitally concerned and interested if a program for improving and maintaining good teaching becomes established even though it may have many imperfections. *Positive action is needed, and administrators must lead in this positive action.*

Coming back to the point on the need for an understanding of what constitutes good teaching it is apparent that if we are to do any effective training in graduate schools, in in-service training programs, and if we are to evaluate good teaching, we have to know of what good teaching consists.

In the teaching process, we are not really concerned with teaching per se but with learning as reflected in changing performance. Without learning having taken place it does not make any difference what the teacher or administrator thinks about the quality of the teaching. There is no teaching in such a case.

How does learning take place? Does it come directly from lectures, from discussions, from instructor-centered class operation, from student-centered class operation, from a good voice, good dress, or from other things or combination of things? If, when learning takes place, we are modifying our nervous system

* Presented at the Annual Meeting of ASEE, University of Illinois, June 17, 1954.

relationships as indicated by the psychologist, and if that is basic to a change in behavior or performance, then how are such changes brought about? Changes appear to be brought about in the nervous system by activity. That would mean that learning takes place through activity of the individual who is trying to learn. Changes in the nervous system response cannot be brought about directly by anything outside the individual, such as the instructor for example. Thus we come to the conclusion that learning takes place through the activity of the learner and that there can be no such thing as direct teaching. Teaching goes on when learning takes place and learning takes place only when the individual is active. We must realize that the learning will be in line with the particular activity going on since only that portion of the nervous system concerned is being primarily affected. Another generalized way of stating the above is that all education is self-education.

Basic Concept

This basic concept needs to be understood and accepted if we are to effectively improve teaching through the triumvirate. It plays a strong and important part in all three phases, in establishing not only a basis for the material in training programs in the graduate school and on the job, but also in the conduct of such programs and in any plan of evaluation of teaching.

If the above is accepted as basic, then it becomes evident that what constitutes good teaching involves producing activity of a kind that will advance the performance of the student in a given field in which we are trying to improve his proficiency. The character of the performance needs defining because that will determine the kind of student activity necessary.

What are the factors involved in this change in performance or in the learning situation that are mainly dependent upon another individual, the instructor? Fortunately we have the results of at least three comprehensive statistical studies; one made at an undergraduate college with no research or graduate work; one made at a large liberal arts college, part of a large University where undergraduate, graduate work, and research are involved; and a third made at a middle-western university where a study was made of graduates who had been out of college for ten or more years.

Through a study of the above investigations made in a graduate seminar and with the help of graduate students, many of whom had teaching experience and who had served on faculties at other institutions than my own, we arrived at four prime influencing factors which we call the four elements of good teaching. The studies gave enough data to make it possible to rank the elements in order of importance, but this does not imply that all four are not of major importance.

These elements are:

1. Motivation. (Every act and every word of the instructor motivates or discourages. Each individual student must be motivated. This brings in the concept of individual differences. An understanding of the feelings and reactions of others is essential.)
2. The ability to explain. (This also affects motivation and can be used as an effective motivating device upon appropriate occasions.)
3. Competence in the field. (Must be fully adequate for the level of student activity involved.)
4. Organization. (Makes clear to the student, curricular, course, and assignment relationships. Provides clear cut and understood objectives for the course and the assignments in the course. Provides effective learning situations into which the student can enter. Provides appropriate learning materials.)

It would make a too extensive discussion to go into great detail on each ele-

ment but I believe enough has been given to make clear what is meant by each element.

If a man learns only by his own activity, both physical and mental, that is if all education is self-education, then we might examine the four elements in the light of this point of view.

The learning situations, into which the student must enter, are provided through the organization of the material of a course. A poorly organized course will not provide good learning situations and without fully satisfactory learning situations, effective and efficient learning cannot take place.

In the learning situations, if time were unlimited, it might be advisable to let the student work himself out of his difficulties because he learns by his own activity. But since time is very definitely limited, the student may need help at certain difficult places. He can be helped through an instructor's ability to explain, and in the explaining, the facts that the student learns only by his own individual activity and that he needs motivation must be kept strongly in mind by the instructor.

It is apparent that to set up excellent learning situations and to be able to explain, the instructor must have the necessary degree of competence.

Motivation is Essential

With situations set up to accomplish the functions of learning, the student will need to enter into the situations that are planned by the instructor, for learning to take place. This calls for the best in motivation. Without motivation of the student the other factors cannot properly function. If the instructor provides the best possible learning situations, has the competency in the field necessary to plan the situations, has the ability to answer questions in a manner to produce the most learning by the student, and provides the strongest possible motivation to produce the greatest appropriate individual activity in the field being studied, the statistical studies indicate and my own experience indicates that maximum learning takes place and if maximum learning takes place then the best job of teaching is being done.

Because all human beings (including both students and instructors) are different, we never have ideal performance. Individual differences mean that when the instructor has to deal with more than one student at a time as he has to do, even if the elements are accepted as basic by the instructor and every attempt is made to have the best in each element, he will have to compromise and attempt to have the best over-all effect for the group. The ideal situation appears to be one student at one time for one instructor. Studies which I made a number of years ago and covering several years indicated that various methods and techniques could be used to reach fairly effectively about 80% of a group of students. When changes were made to reach as many of the remainder as possible, some of the original 80% were always lost so that I was unable to greatly exceed 80% except by one device and that was by giving individual attention.

The same instructor with varying student groups from term to term will not be able to accomplish the best results that he may be able to accomplish every term. But I firmly believe that an instructor who recognizes and works to make the elements as good as possible will end up doing the best possible over-all job of instruction and a good plan of evaluation should show this. The instructor who can not or does not set up good learning situations, who cannot explain satisfactorily, and particularly who cannot motivate students or even may produce a discouraging reaction in the students will not have effective learning take place and he would be classified as a poor teacher.

We will now give attention to the relationships between the four elements and the three phases for improving and maintaining good teaching.

The first phase is the training of prospective teachers in the graduate school. I do not propose to suggest a whole program of teacher preparation but merely want to point out some things that are involved if the four elements are accepted. If we learn by our own activities, then the only way we can learn to teach is to teach but that does not mean throwing a young man blindly into a classroom filled with students, and I believe that has been somewhat the national practice.

There are some things which the prospective teachers will do well to recognize. Teaching is an art and one can only become proficient in an art by an intelligent practicing in it. That limits the extent of benefits possible from formal course study. The graduate school therefore is limited in what it can do effectively, but an examination of the elements indicates there may be some things that are worthwhile doing that will help produce a better teacher.

Can we develop a man's abilities to produce motivation in others through formal course work? That would appear very doubtful in the light of the way we learn. One, in my opinion, learns how to motivate others for learning purposes through the actual handling of students and being wise enough to analyze how his own personality and actions impinge upon the student and what effect is created. This calls for actual teaching and if it is possible to use graduate students interested in education under supervision of someone who understands good teaching and who can use it in his own dealing with prospective teachers, then it becomes possible to help the coming teacher understand himself in relation to students. This could be called a teaching internship. However before taking up the internship, the prospective teacher could take some formal work in the psychology of learning and of motivation both of which could help him start his development as a teacher and could supply a basis for self-appraisal.

Ability to Explain

The development of the ability to explain lies in the actual practice and study of results of one's own explaining. This means actually teaching under supervision.

Competence in a given field is a prime objective of graduate study and is already being well taken care of by the various subject matter groups.

Training in organization as defined here must be carried on by actual preparation for actual teaching, again under supervision. Factors affecting motivation, whether we desire them to do so or not and growing out of organization are, tests and examinations, other devices used as a means of measurement, and the grades themselves which are the numbers or letters taken from a measuring device. A study of tests and examinations and a study of educational measurements therefore would seem to be desirable. If we were to include a study of student personnel problems, I believe we would have included nearly all of the formal study that would be of value. The studies above could be presented through formal courses or preferably through a series of appropriate graduate seminars. Through the seminars and their handling (the seminar itself should serve as an excellent example of good teaching), covering the four topics mentioned above, and through a limited, and in a sense, an introductory amount of apprenticeship teaching under appropriate supervision, the graduate schools could make their contribution to the improvement of teaching.

Since we learn to teach by teaching, a continuation of the training in the graduate school is called for, for perhaps a year after a young man is on the job. This program should be developed in such a way as to enable the young man to bring the four elements into full play for the best learning results. It might involve a review of the teaching background introduced in the graduate school. This could be followed by a considera-

tion of any items of particular importance to the institution concerned. The in-service program might be completed with closely supervised teaching in which the same type of relationship might exist between the young instructor and his supervising professor as exists between the doctorate student and the professor who directs his research.

I feel confident that a young man who has taken the seminars mentioned, who may have had an opportunity to have served in apprenticeship teaching for at least one term, and who has received special attention through an in-service training program would end his first full year on the job in a much better position to develop himself into a good teacher.

With these two programs worked out to a fully satisfactory operating condition, we would be providing the means for improving teaching but not maintaining good teaching. We must have proper recognition and incentives to maintain good teaching and to have these we must first have evaluation.

The four elements can serve not only as a basis for setting up training programs but also as a base for a workable plan of evaluation that would not be too cumbersome or so detailed that it would lose significance. The evaluation can not only serve as the base for recognition but also as a means for each individual to have a measure of his own development as a teacher. It can provide the information which every teacher needs to know about himself to enable him to continue his development to a still higher level if possible.

Before anyone's teaching can be evaluated, appropriate information about the teaching must be available. Without such information no one's teaching can be evaluated. It is the acquiring of the essential facts that is the problem of evaluation. If the facts are available then someone capable of doing so can proceed with a plan of evaluation. The facts to be gathered must of course be in line with the plan of evaluation.

Four Elements

The four elements provide the character of the information that we need. We need facts on each of the four elements if we accept them as the backbone of the educational process.

The question can be raised, who can report on motivation? The students are on the receiving end. It appears to me that they are the prime ones, as a group, to give information on motivation. An individual student has some idea in regard to whether or not he is being affected in certain ways in the course and with a plan set up, he can render a valuable report. If motivation is accepted as the first basic element then we need a scale from which ratings can be determined. I would not attempt to discuss that here; that is an additional problem, one with which the psychologist could help us.

The second element is the ability to explain. Again the student is on the receiving end. The question is not whether the professor understands what he is explaining or that another professor understands; it is whether or not the student understands what the professor is explaining, and if the student does not understand then the explanation is lost, and educational benefits are lost. The effective use of explaining involves motivating the student to think. The student is the one that can report best on explaining. Ability to explain is placed in second place, the relative position coming from the statistical studies already referred to.

The third element is competence in the field. This in my opinion can be reported upon by a man's colleagues in the field. Advanced study and scholarly work provide additional information.

The fourth element is organization. Under this item comes the promulgation of the objectives of the whole course and of each individual assignment so that the student knows where he is going and why. Also included under this item are the situations which it is necessary for the

instructor to set up in order to provide learning conditions. I believe data on this element can be obtained by an examination of tangible materials of the organization (teaching materials including tests) which any instructor should have available for examination as well as from some reporting by students. Thus the obtaining of appropriate information in my opinion, depends upon students, upon a man's colleagues, upon a man's scholarly record, and upon an examination of the material which the man prepares for use in his teaching.

If a workable scale can be established under each of the first two elements, a scale that can be used by someone carrying out the evaluation, if one can be set up by which a man's colleagues can provide for the evaluating of competence in the field, if provisions can be made for the evaluating of his teaching materials and other factors affecting organization, and if all results can be combined, arriving at one over-all rating, I believe we would have a basis for the evaluation of good teaching. If we can arrive at such a base then it can form the foundation for recognition and for promotion in rank and salary in which teaching will play its full part. This will do more to focus the attention of faculty members on good teaching than anything else that I can think of and it can provide the best and perhaps the only way to maintain good teaching.

Evaluation

Evaluation of a sort goes on all the time but it can hardly be called a sound valid and reliable evaluation in so far as teaching is concerned. We now have a kind of evaluation going on more or less continuously based upon the chance reports of a few students and faculty members. In the case of faculty members, they may only transmit chance reports that originated originally with students. I do not see how there can be real and fair evaluation without planned reporting and the reporting should be set up on a sound basis that will make the results of the reporting of maximum dependability, over-all accuracy, and utility for evaluation purposes.

Let us have a planned reporting, followed by a sound plan of evaluation which can lead to real recognition for the prime work of the college, the work of teaching.

College Notes

An international meeting of over 200 educators and engineers was held at **Clarkson College of Technology** October 6–8. William G. Van Note, college president, announced that the American Society of Mechanical Engineers and the Engineering Institute of Canada have accepted the college's invitation to hold a convocation on "Trends in Mechanical Engineering Education." Among the topics to be considered during the convocation will be "Can Present Mechanical Engineering Curricula Be Improved?" "Dangers of Overspecialization in the Curriculum," and Post-Graduate Education in Education."

* * *

Harry L. Daasch has accepted appointment as a professor in the Department of Mechanical Engineering at **Colorado A & M College.** He will act also as department head during the next two years while the present head is serving for the College at the University of Peshawar, which it is sponsoring under an F.O.A. contract.

Recognizing and Rewarding Good Teaching*

A Preliminary Report of the Committee on Recognition and Incentives for Good Teaching

By R. W. SCHMELZER

Chairman of Committee; Assistant to the President, Rensselear Polytechnic Institute

In an Abstract Report of the Stanford University Committee on Evaluation of Engineering Education, the following statement appears:

. . . there are only two important factors in the educational process, the student and the teacher. The rest—curriculum, administration, structure—are unimportant except as they influence the effectiveness of student or teacher.

The raw material, the student, is to considerable extent out of our control—the second factor is the one we must work with. We shall have improved education of engineers only when we have more good engineering teachers working in an environment in which they can function effectively.

The Committee on Recognition and Incentives for Good Teaching was charged with examining the role of good teaching per se as it affected the status of the faculty member. It is still in the process of its examination.

The committee is a large one so that a great deal of its correspondence is done with the aid of a mimeograph machine. Since it is relatively easy to grind out a few extra copies of each item of correspondence, the officers of this Society were unfortunately kept too well informed about the discussions going on between committee members. Although no conclusions have yet been reached by this committee—with the exception of one or two areas of almost unanimous agreement—the officers felt that the ideas of the committee had reached a point where they might be presented in a meeting such as this so that additional ideas and opinions could be obtained. This, then, is a report of the opinions of people both within and outside of the committee about the recognition and rewarding of good teaching.

Almost from the outset, the committee addressed itself to the problem of whether it is possible to measure objectively the results of good teaching. In connection with this problem, it had the advice of the Chairman of the ASEE Division of Educational Methods, and it also had the advice of two distinguished psychologists in the field of personality measurement. One of these, Professor Gordon Allport, Professor of Psychology at Harvard University, said, "My guess would be that there are so many ways of being a 'good' teacher and so many ways of being a 'bad' teacher, that no uniform scale is possible . . . it might be feasible to develop a record or rating form that an administrator might use to keep track of specific attributes of teaching that would help him reach an over-all judgment concerning the excellence of a given instructor. Such a broad (rating type) of guide might be better than the 'intuition' that is now employed by administrators, but it will still fall far short of the mathematical formula that some enthusiasts might desire."

* Presented at the Annual Meeting of ASEE, University of Illinois, June 17, 1954.

Professor Hadley Cantril, Professor of Psychology at Princeton University and Head of the Office of Public Opinion Research, said, "I quite agree that the problem is perplexing and has many variables. However, I do think that there are certain aspects of being a 'good teacher' which are generalizable and might form the basis of some further inquiry. . . . Obviously, there are enormous personality variables here that I suspect can never be 'taught' or 'improved' if a teacher just happens to be built the 'wrong' way for his particular profession."

Dean Sweigert and the Educational Methods Division have already done much to clarify ideas concerning the recognition of good teaching, although in the committee for which I am reporting, there are some reservations as to the significance of student rating of instructors. But before areas of difference are discussed, it might be well to mention areas of agreement.

First of all, it is accepted without question that the good teacher must of necessity be a good person. He must have wisdom, honesty, interest in people, a knowledge of his subject, and so forth. But desirable as these qualities are, the possession of them alone does not automatically make for a good teacher.

Qualities of a Good Teacher

Professor Cantril lists three aspects or qualities of being a good teacher to which the committee subscribes. These are:

1. A real ability on the part of the teacher to understand the purposes of his students; what they are trying to get out of the course; why are they taking it; how can their personal purposes be brought into the teaching?
2. The use of concrete illustrations at the beginning of discussion on almost any problem no matter what it is; arriving at abstractions only fairly late in the discussions. . . .
3. Indicating at the beginning of a course what the course is all about—then giving the course—and then at the end making a fairly thorough review of what the course has been all about—that is, trying to wrap it up in a package.

The committee also recognizes that teachers are employed to produce certain specified, desirable effects. One of these is introducing students to a subject. Another is carrying them along in the subject in the intermediate stage. And still another is carrying them up to the frontiers of knowledge in a subject. A teacher who is adept in producing one effect and performing one function with students may be quite ineffective if asked to produce other effects. Similarly, some teachers may be particularly stimulating to good students but may have little or no beneficial effect upon average or poor students. A wise administration recognizes these differences and uses its teachers where they can be most effective.

As Professor Glenn Murphy of Iowa State College says, "The objectives of a freshman course in engineering drawing are different from the objectives of a senior course in aeroplane design. Consequently, if absolute and not relative measures of performance are desired, different sets of specifications must be used in evaluating the teacher's performance in each course. We all know of teachers who are far more successful in teaching one group of courses than another.

"In establishing what we should expect from a good teacher in a given course, we should take into account the fact that each course has four types of objectives. In each course, we want the students to acquire certain bits of factual information that will be useful later, we want them to acquire certain manipulative skills (such as using a slide rule or steam tables), we want them to develop an understanding of basic principles and their applications, and we want them to develop whatever native ability they may have for thinking."

Dean Hazen of M.I.T. in "A Letter to a College President" says, "We are skeptical of the man whose course has not changed very appreciably in the last ten years in orientation, outlook, and selection of subject matter." To be effective in communicating with growing minds, the mind of the teacher must also continue to grow.

Obviously anything which challenges the mind of a teacher, which causes him to work to the best of his ability in his chosen field, is not only desirable but is a necessity if we accept the truth of the preceding statement. Here then is the real role of research, of publication, and of consulting in the teaching-learning situation. All of these activities demand the best efforts of the teacher; they keep his mind razor sharp; enable him to stand as an equal among his peers and thus give him confidence and self-esteem; and they enable him to bring to the classroom a wealth of current illustrative material.

An article on university research in a college alumni magazine states, "The climate of the graduate school with faculty interested in contributing to knowledge and organizing advance material for study, with students anxious to try out their own ideas, seeking council of those already well versed in research, keeps in balance those factors so necessary. . . . Not only is the educational effort of the professor made more successful, but this is also the best method by which the professor may secure professional recognition." Is this latter statement that "this is also the best method by which the professor may secure professional recognition" necessarily true? And, if it is true, the committee asks, should it be?

A Teacher's Profession is Teaching

Professor Nudd of Cooper Union has strong convictions on this subject and writes,

> A teacher's profession is teaching. A teacher should be an authority on teaching. The significant field of his scholarly attainments is teaching. His significant research is in teaching. Judgment of his attainments which are significant to his reward for employment as a teacher should come from peers who are teachers. Adequate knowledge of the subject taught is the least of our problems in obtaining effective teaching. The confusion in evaluating a college on the basis of its teachers' erudition rather than on that of its students is responsible for a large share of our difficulties. There may have been times when lack of knowledge of the subject taught was an important handicap to many teachers in our engineering schools, but this is certainly not true today. Our problem is to induce teachers to provide effective experiences for the students. Teachers who have won distinction in activities other than teaching should not be rewarded as teachers unless they have matched the non-teaching activities with effective devotion to teaching.

Let us assume for the time being that if it were possible to do so, teachers would receive recognition and rewards primarily for the excellence of their teaching rather than for their associated activities, important as these might be. How then is the quality of the teaching to be recognized? By whom and in what manner?

As might be suspected, the members of this committee are much less unanimous and much less definite in regard to methods of recognition. The growing custom of student rating of teachers is regarded by the committee as of value chiefly to the teacher himself and not to department heads or deans. Several members of the committee feel that student ratings tend to give undue emphasis to entertainment value, geniality and other personality traits, rather than to more significant and possibly more lasting values in teaching.

It is, however, certainly true that motivation plays a most important part in the teaching-learning process. Obviously, the teacher who discourages or kills motivation on the part of his students is a menace and should not be tolerated. Students are, therefore, in a position to report upon motivation. They are also

in a position to report upon the suitability of the course to their stage of learning—that is, they are well able to report whether the course repeats unduly what they already know, or whether the course assumes that they know more than they actually do.

The ideal situation would be to have an assessment by the graduates five or ten years later. But such an assessment would be extremely difficult to carry out and it frequently might no longer apply to the existing situation.

There is, of course, one excellent way for a teacher to find out for himself what his students think of the value of his own teaching. He would, in order to try this experiment, need the cooperation of the members of his department and the consent of a dean or two.

It is simply this. After his course has been running for, say, four weeks, let him announce to his class that the final examination in the course will be written and graded by a committee of the college faculty—that he will have no hand in either the examination or in its grading. He, however, will plan to meet with his students at the regularly scheduled times, but that he is giving them an outline of the material to be covered by the course and that there is no obligation on the part of his students to attend any further classes. They may come if they find the classwork helpful or they may stay away and study on their own.

Gauge of Teaching Effectiveness

All the teacher has then to do, after having made this announcement, will be to watch class attendance the way a theater manager watches his box office. If the attendance is good, the students will undoubtedly feel that they are getting something out of his teaching. Of course, a few students may attend out of sheer superstition and a few others out of sheer habit, but by and large if students feel that there is no need to attend and that there will be no retribution for not attending, their presence or absence will be significant. It should be a far more accurate gauge of teaching effectiveness than any student-faculty rating sheets yet devised.

The foregoing is not meant to imply that teachers should play a secondary role in education in favor of impersonal final examinations. The committee believes that the engineering student needs the teacher's aid in creating situations for learning where the emphasis is not on memorizing and testing but on practice. In these situations the teacher can observe how the student analyzes and attempts to solve the problem, with the teacher simultaneously giving aid and encouragement and evaluating progress. Because engineering is creative and productive, examinations which merely test the amount of information the student has acquired and memorized may fail completely to evaluate properly the creative and productive engineering ability of the student.

Although students as recipients of teaching should be in a position to evaluate it, in actual fact, recognition and reward for "good" teaching can only be brought about by the people whose responsibility it is to recognize and reward teaching; that is, by department heads and deans. This, in the opinion of a majority of the members of the committee, is their specific responsibility. And they already have at hand a great many ways of measuring teaching effectiveness. They have outlines of courses, examinations written by the teacher, teaching devices and aids that are particularly effective and that receive favorable attention by the teacher's colleagues. Then, too, there is the general respect that the teacher receives from colleagues and teachers in his field. Furthermore, there is the quality of mind and performance that he demonstrates in his university duties as well as his publications, his research accomplishments, and his industrial relationships.

Dean Jamieson of McGill University says that he believes that "teaching quality is of paramount importance in

the undergraduate years, and that 'good' teaching *can* be assessed, albeit not quantitatively. The teaching of undergraduate courses, as a major interest for all members of the staff, must carry adequate reward by way of salary and position in the profession. This does not dissociate the good teacher from creative activities. The expression of his development lies in his stimulating and progressive teaching. Research will have its place in his work, but not always a major place. We must not give undue weight in the way of incentives, to graduate teaching, research, published papers and so forth."

This statement by Dean Jamieson is a fairly accurate summary of the thinking of the committee at the present time. Throughout all of the divergent opinions cited in this report, one unifying theme appears. That is the concept of good teaching resulting from creative activity on the part of the teacher. The one important prerequisite for good teaching appears to be a growing mind. Whether that mind is growing as the result of a search for better teaching methods, for more knowledge, for better methods of applying knowledge, or for various other reasons is apparently not so important as the fact that the mind of the teacher is growing. When the mind stops growing, it starts dying.

Further Investigations

Your committee would like to make further investigations regarding two somewhat related points. These are: (1) to continue to determine whether it is possible to measure objectively the results of teaching, both good and bad, and (2) to study the present methods of rewarding good teaching per se.

The question of teaching ability versus knowledge is one that must be solved by each university and each department in its own way. So much has been said upon both sides of this issue that the committee approaches this problem with great reluctance. Certainly no one would hire as a guide in frontier territory a person who had never been there. On the other hand, undergraduate education in engineering and science travels through fairly well-explored regions, and many people who have never been to the frontier are completely familiar with these regions. These people serve not only as adequate but frequently as excellent and inspired guides.

There do exist techniques for creating a greater awareness about certain aspects of our national life and institutions. These techniques have been used quite effectively in the fields of propaganda, advertising and public relations. Perhaps what is needed in relation to the question at hand—that of stressing the importance of teachers and of the teaching-learning situation—is simply to give it more of an airing than it has had in the past. Perhaps, by the use of some of these techniques, we need to create a climate of opinion so that the man who devotes himself primarily to teaching won't feel apologetic about it—won't feel that he is not a valued member of the university community; won't feel that he is playing second fiddle to a researcher or a writer of textbooks; won't feel that it is somewhat futile to devote his efforts to making himself as good a teacher as he possibly can. Perhaps, just by taking thought, we as a Society, can add a cubit * to the stature of the teacher.

* 18".

The Munificent Gifts That Lead to Good Teachers*

By E. C. THOMA

Associate Professor of Civil Engineering, Purdue University

It would be unjust to limit these munificent gifts to engineering teaching alone for most certainly all teachers will agree that it is the generous giving by most teachers to all of their students that has aggrandized this oldest of professions to all mankind. Teaching is the root, the beginning, the source of growth of Man. So it was with the Ancients and so it is with us. Someone—a mother, a father, an elementary or high school teacher, a college professor—has been a sower of seeds and a generous counselor on the fertilizing of ideas so that the sprigs of Man could take root and grow.

But let us be more specific; let us view these roots that our gifts of good teaching will develop. Naturally these gifts will be as I see them and, therefore, somewhat opinionated rather than built wholly upon facts. Most assuredly teaching is an individual portrait and what seems best for a certain personality may not blend to the color and characteristics of another personality. However, we must all concede that every good teacher has developed certain traits of common good. It is these traits—these munificent gifts —I shall discuss.

I. The Teacher's View of His Profession

Effective teaching can be influenced through an appreciation by all teachers that, regardless of the subject each teaches, their goals are akin. It was once said, "Any teacher must appreciate that a more complete education—sciences, arts, humanities—is best achieved under a unified program rather than fragments through departmental learning." Therefore, an attitude of 'for the good of the whole' must preface a teacher's individual thinking about his profession.

This professional attitude is determined to a large extent by the administrators—the deans, the department heads, the section supervisors. I have been most fortunate in this respect—from the very top to the very bottom of the administration ladder. It is a heritage due every teacher. Professional esprit, the zest and the zeal to do a good job, must be spotlighted by those who hold in their power a small measure of another's destiny.

II. The Teacher's View of Himself

Like any other successful individual the teacher must have confidence in himself, his school, his profession. Dean Harry J. Carmen of Columbia College, Columbia University, ably expressed the traits so necessary in a teacher when he said that teachers should be "persons of attractive personality, insight, sensitiveness and prospective—persons who have a happy disposition and a sense of humor and who have an urge to be guides, philosophers, and friends of students. . . ."

Certainly we all agree with Dr. A. D. White's report made in 1866 to the trustees of Cornell University to the effect that good teaching must develop mental discipline—the discipline of keenness, precision and breadth of mind. A lack

* Presented at the Annual Meeting of ASEE, June 17, 1954, University of Illinois.

of breadth, so goes the report, "fails to make men." If the young men and women of today are to be the leaders of tomorrow, the teacher must have moral strength, an inquiring mind, an inspiring spirit and a watchful eye so that he can direct the development of mental discipline.

Education is the gathering of factual information and then employing it to a creative end. Therefore, education is a process of self-learning and self-thinking. The good teacher is his own best student. The good teacher—the effective teacher—is one who stimulates the student to be the teacher of himself. Certainly a student must have guidance to distinguish between facts and opinions. However, this guidance cannot be the type whereby the teacher marshalls the development of individual thought.

When the effective teacher takes a periodic blood count on his students, he unquestionably can number these growing organisms that he has helped to sow: (1) sufficient factual information to keep the students' self-teaching on the right road; (2) self-teaching stimulants—spirit of inquiry; (3) confidence by the students of their ability to teach themselves; (4) integrity—a moral code of their own which is above reproach; (5) a strong character; (6) a desirable personal philosophy; and (7) a standard of achievement second to none.

III. The Teacher's View of the Student

In the student the teacher sees youth and spirit, that tangible product of Man that spells continuance of growth and progress. The teacher sees reflections of himself in an era some years past. The good teacher casts these reflections forward to light the path of his students with those very things he saw and sought for himself—an individual of inquiring mind motivated by sound character to worthy and attainable ambitions. But how is the good teacher going to be sure that the students stride toward that goal? The good teacher remembers that:

(1) His classes are composed of as many individuals as there are students enrolled;

(2) Only by his own enthusiasm of spirit and interest will he be able to inculcate in every student the desire to learn his subject's related position to the end product—an education;

(3) Only by a reasonable amount of effort, by sweat and determination, can all students reach the top of their individual ladder of success. Therefore, a sternness to do the job at hand is necessary. College students respect and follow the instructor who treats them for what they are—adults. The instructor who permits the back-slider to slide unbraked, who permits the student to commit a "breach of educational contract" without being admonished, who establishes a set of procedures and rules for educational conduct and then ignores them—all these and similar attitudes, will lose the respect and confidence of his students.

(4) Every individual thinks himself to be an important person in the world. Therefore, good teaching strives to encourage and build personal confidence—bearing in mind, however, that the confidence to be achieved is not a cocky, obnoxious, "I can do no wrong" type.

(5) Good teaching encourages each individual to seek his own level of attainable goals. An alidade is the vernier of an optical instrument. I like to think, then, that the trait of displaying good judgment is the vernier or alidade of that optical measuring device, the mind. It only stands to reason that kindness, fairness, candor, tolerance, understanding and courtesy are displays of good judgment in finding avenues of approach into the inner sanctorums of the individual student.

And so one could go, on and on. In attempting to define the labors of good teaching we could say it is the striving to develop within each student a spirit of self-inquiry—an intellectual curiosity, if

you please—to obtain a knowledge of concepts and principles reinforced with the ability to communicate to others in a courageous, sincere and industrious fashion a solution developed from a logical analysis of the precepts involved and synthesized to the particular problem under consideration.

We now can appreciate what Jacques Barzun meant when he said, "The ramifications of teaching are so numerous and so singularly significant that a true concept of the ideal entity often is lost." Reasonable as this statement may be, we must admit, too, that our teaching technique can be evaluated with a pointed self-inquiry; namely, have my teaching procedures helped build that ship of destiny—CHARACTER; rigged its sails of mental growth—INTELLECTUAL CURIOSITY; and seeded a hurricane to assure it motion—AMBITION? If so, the munificent gifts or traits of the good teacher are yours.

College Notes

Astronomers and electrical engineers at the **University of Pennsylvania** have joined forces in a concerted program to pioneer new electronic methods of observing the stars, Carl C. Chambers, vice president in charge of engineering affairs, announced recently.

To foster the development of new observation aids, the University has established a "working partnership" between its Department of Astronomy and its Moore School of Electrical Engineering.

* * *

John Fyfer Calvert has been named Professor and Head of the Electrical Engineering Department at the **University of Pittsburgh.** Dr. Calvert has been professor of Electrical Engineering at Northwestern University since 1938 and has served as chairman of the department since 1939. He was formerly associate Professor in Electrical Engineering at Iowa State College from 1936–38. From 1925 to 1936 he was associated with the Westinghouse Electric and Manufacturing Company. During this time he took part in the Westinghouse program at the University of Pittsburgh serving as a graduate lecturer.

* * *

The appointment of James Michalos as Chairman of the Department of Civil Engineering at **New York University's** College of Engineering, was announced by Dean Thorndike Saville. Now Chairman of the Department of Civil Engineering at Iowa State College, Dr. Michalos replaces Thomas C. Kavanagh, who has resigned to work with the firm of Praeger and Kavanagh Engineers on a full-time basis. Dr. Michalos is an authority on structural analysis, mechanics, and design theory.

Philosophy of the Cooperative Program*

By PROFESSOR CLARENCE E. WATSON

Chairman, Dept. of Industrial Relations, Northwestern University

The basic philosophy of the cooperative program lies in its experience value. The professions of law and medicine, for example, both require rather lengthy periods of apprenticeship before the professional society will recommend a man for public practice. If, then, our training of an engineer is to be complete, we must provide first hand experience in industry with the men and machines with which he will work. Such work experience challenges the student with events which hit hard at his personal life and habits. This personal challenge cannot be attained by an academic curriculum alone. By this method, as in no other system of formal education, students are brought in direct contact with the American system of free enterprise.

Until the time of cooperative work, the student's education has been of an "individualized variety." He has been individually tested, graded, and ranked among other members of his class. Competition has been the keynote, and definite rewards have been paid in the form of grades and subsequent honors. Now, in his cooperative work, he begins to realize that upon joining industry he becomes a part of a most active *team*, be it large or small. As a member of this team, he finds that the tail cannot always wag the dog. A "great" idea oscillating within his own mind does not necessarily effect sympathetic vibrations in the minds of management or other workers. This is often quite a shock to some students.

Teamwork

If there is one thing the cooperative program emphasizes and teaches the student, it is TEAMWORK. One of the officials at the A. O. Smith Company in Milwaukee puts it this way. "None of us can know it all. We can't be thoroughly familiar with all of the many phases of our many sciences and techniques and have the practical know-how of all of our manufacturing processes. There just aren't enough hours in the day or days in our lifetime to permit it. But we can become well informed in one or several spheres and learn as much as we can about the others—at least to the extent that we recognize there is much we don't know and then call upon those who do know to help us. This is team work. It is the priceless ingredient in all present day accomplishment, multiplying by many fold the relatively limited power of an individual. It is the spirit of tolerance of another's ideas or suggestions. You never know when the other fellow may come up with a crackerjack of an idea which you may never have thought about. It is the spirit of patience you show towards the slow thinker who may be basically well informed in another field and able to help you tremendously after he finally gets the idea. It is, in part, the insight you may have into the reaction of others and the ability to get your idea across and make him think it was his. It is the skill with which each member of the team plays his own position and pitches in to help a weak member when he falters. It is the spirit of democracy bowing to the decisions of the majority.

* Presented at meeting of Cooperative Engineering Education Division, ASEE, University of Illinois, June 15, 1954.

Then after the plan of the majority has been adopted, pitching in with all your might to make it a success. It is the philosophy that no man wins when the team loses but everyone wins when the team wins. It is a little bit of a lot of things—a rather complex concept when you break it down into its elements but very simple when stated as 'a group of people pulling together.'" The cooperative student has this impressed upon him early in the game.

The transition from college to practice for the traditional graduate has been likened to an abrupt shift from high gear into low. The graduate comes out "rarin' to go." For the past few months he's been king for a day. Pampered by recruiters and accustomed to expense-paid trips, he sees a bright future with a successful engineering career ahead. He tackles his first job with enthusiasm, but soon finds it growing repetitious. There is a sense of suddenly arrested progress. He begins to feel that he has learned all the job has to teach and wants to move on to a new assignment, as he did in college. He wants to make a showing, quickly, and in his own name. Where he came from, men were judged that way, as individuals. He may fail to see that he is now engaged in an almost unbelievably intricate piece of teamwork, where most of the brilliant individualists are headed toward one-man jobs and where the chief prizes are handed out for contributions to the work of other men. In this new and strange environment he is likely to lose both the impetus and the sense of direction for any effort to get on with his education and to fall into the habit of being content merely to assimilate the day's experience without conscious intellectual effort.

Competitive vs. Cooperative Thought

What I am trying to point out is that there is a marked contrast between the type of competitive thought provoked in a classroom, and the type of cooperative thought which is so necessary to succeed in industry. There is need for helping students to realize this difference and the Cooperative Plan helps to do this.

Professional careers, differing widely in their demands for specific techniques and branches of learning, are alike in one respect; success in any field depends upon ability to cope with the multitude of diversified problems which arise continually and require rapid and accurate solution. The Cooperative Program is invaluable in the early development of such ability.

The value of an educational process is not to be measured alone by the quantity of information which it imparts, but also by the flexibility and versatility which it develops. The vital requisite is a disciplined mind, with the perspective, the judgment, and the ingenuity necessary to derive the greatest possible value from the information available. Consequently, it is of the greatest importance that the most strenuous efforts be devoted to creating a facility for clear and logical thinking, for the proper orientation of the student's point of view and the conditioning of his mental processes. Industry can play an important part in this orientation.

The engineering profession endows its members with a deep social and moral responsibility. The engineer must satisfy the demands of society for an ever-increasing standard of living, using the researches of pure science to produce, through industry, human benefits. In order to undertake successfully such a task, a man who would call himself an engineer must understand: (1) The scientific method of thought and the natural laws of science. (2) The organization and ethics of industry. Industry and commerce characterize much of American culture. By their proper union with education, even greater achievements than in the past may be expected.

Balanced Training

The Cooperative Plan reflects this basic philosophy. It is a coordinated program of alternating work and study. Employ-

ment in industry is a regular, continuing, and essential element in the educational process. The objective is balanced training—an opportunity for the engineering student not only to learn but to practice during his impressionable years.

Cooperative education achieves the objective of an effective program of engineering training in the clearest and the most comprehensive way. The student looks at the field of engineering not only from the academic viewpoint of the thinker who devises machines and methods, but also from the practical viewpoint of the doer who translates them into action. The combination of theoretical training and practical experience invites and encourages a correlation which may not otherwise be possible or expedient, and which contributes considerably to the value derived from each. The cooperative student is spared the unsatisfactory experience of carrying through to completion his academic training before he is given an opportunity to put any part of it to the test of practice. With the principles taught him in class and the laboratory fresh in his mind, he takes his place for a brief period in the midst of industrial activity. Here the broad understanding of practical procedures is impressed upon him. His period in industry completed, the student returns to college and finds that his academic work assumes a new and interesting significance. Combining theoretical training and practical experience encourages the student to correlate the two. The perspective gained should enable him to enter industry a more mature and understanding person.

Knowledge is a Mode of Doing

The Cooperative Plan teaches the student to deal with situations which are without precedent and which involve human beings, not merely theoretical problems. It can help the student to see his profession not in terms of applying formulae, but as a continuous filling-in of the unknown. The student experiences life before the full responsibility of it is his and while the college can still interpret and help in the process. There is more to it than periodically thrusting the student out of the academic nest. The usual non-coop graduate is often plunged from the regulated artificial set-up of the classroom, where all effort has been directed toward *him*, into industry where he is of little importance, where he is thoroughly bewildered and often disappointed, a world for which he is often inadequately prepared. There is small value in a college education which is unrelated to life experiences in the process itself. "Knowledge," to quote John Dewey, "is a mode of doing."

The Cooperative Plan cultivates an attitude of mind that makes intellectual pursuit, civic responsibility, and social development natural expectancies. It teaches the student that there is no future in any job but that the future lies in the man who holds the job. It teaches the student that the greatest under-developed territory in the world lies under his hat. It makes him realize that good education is not the art of allowing others to do for him as much as he has the capacity of receiving, but is rather the measure of his own self-preparation. In the final analysis, education is what you have left after you have forgotten most of what you learned.

We are, perhaps, too prone to think of engineering education as education about things. No education is complete without an education about people. Cooperative courses teach students to get along with people and to appreciate the personal problems of various social and economic groups. This is most important as the complexity of our society increases. Cooperative education puts the emphasis on what we *don't* know, as well as on what we *do know*. It promotes a questioning mind along with a close relationship with modern industrial practice. Students hunt for information rather than depend upon someone else to organize it for them. These are qualities which

promote maturity, emotional stability, sound judgment and courage.

The following is a quotation from a concluding paragraph of a work report recently handed in by a student in chemical engineering at Northwestern University after completing an industrial assignment. "There can be little doubt as to whether or not the last period of cooperative work was profitable. In practical experience alone the value is more than can be measured. Then, too, one learns a bit about giving consideration to the other fellow, something we seem to forget in the pressure of our studies. But more than these, there is something gained which lies beyond that immediately apparent—that thing is a purpose. Education is a mockery if we lose sight of the basic things for which it was intended. In my opinion, the cooperative system adds purpose to education."

Promotes Mutual Respect for University and Industry Accomplishment

Dr. Herman Schneider, the originator of the Cooperative Plan at the University of Cincinnati has said, "There is a by-product of the system which defies phrasing—it is a quality that comes from being required to face the day's work squarely and successfully. It comprises the development of a silent strength of will combined with honest judgment rather than capricious criticism. It is a good thing for a man to sweat his way toward the truth." Dean Schneider's concept of education has both increased the respect of the University Campus for practical industry and cultivated among men in industry a new respect for University accomplishment. The Cooperative system is truly the American Way.

In the News

At a special reception at the French Consulate in New York City, the French Legion of Honor was conferred upon Dr. D. B. Steinman, internationally eminent bridge engineer on his birthday and the eve of his sailing for Europe. During his European tour he received many honors, including an honorary degree at Bologna, a gold medal at Rome, receptions and honors at Brussels and Ghent, and culminating with four medals and three decorations at Paris.

To meet "the pressing problems of nuclear engineering and the related sciences," with particular interest in "industrial usefulness," **Engineers Joint Council**, composed of major American engineering societies with a total membership of 170,000, announced initial steps toward an organized program of confronting these problems "authoritatively by a group of leading engineers."

In making the announcement, Thorndike Saville, President of the Council and Dean of Engineering at **New York University**, commented that "action by this powerful engineering group is further evidence that nuclear energy is well on the way to having important peace time industrial usefulness."

The Initiation of Research*

By WALTER C. VOSS

Professor of Building Construction, Emeritus and Lecturer, M.I.T., and Consultant in Architectural Construction and Materials

The old cliche "Necessity is the mother of invention" might be broadly rephrased "Research is the price of survival" in order to set the stage for our discussion of research. Living as we do in an economy and a country where ideas and perseverance are rewarded, we find our lives are surrounded by the activities of persons and groups striving to capitalize on their ideas and to improve their status by an endless array of approaches, some scientific, some commercial and some only so-called hunches, which they hope will provide the solution to their ever present needs for progress. Such activities command the indulgence of those involved in business ventures, educational improvement, advancing the science of health, social welfare and government problems. In each of these fields there is a continuous demand for ideas and methods to provide solutions for the mandatory needs required to maintain or accelerate progress. The urgency of these needs stimulates "trial straws in the wind" to test practicability or forces the decision to study the problem carefully to test the validity of what often are preconceived hypotheses.

These efforts may be said to prompt the initiation of research. Without going into the classic discussion of fundamental and applied research, it can be said that no research in any basic field ever starts without the stimulus of a growing need to remove the penumbras of doubt and the lack of knowledge in that field. Once the need is recognized there follows a period of analysis of related work and the preparation of an initial program. The preparation of the necessary equipment and the conduct of required tests follow. When some semblance of a solution emerges, the newly found ideas are checked by preliminary trials or pilot runs. If these justify the conclusion that the approach is practical and exploitable, the first stage of the research is completed. But this is not the end in the usual case. When the success of the first effort becomes known by any one of many ways, others adopt the springboard of this initial work to solve problems which they may have thought hopeless because of the lack of the newly found facts.

Follow Progressive Pattern

After the initial efforts and perhaps after one or more successive applications of the effort are made, it is very often the case that other investigations related to the original efforts are undertaken which are based wholly upon the desire for pure fundamental knowledge. The whole broad field of research is filled with a great variety of objectives from those based on purely personal or commercial expediency to the purest search for the extension of knowledge where no advance conviction that the facts when determined will have any immediate applicability. All of these follow the same progressive pattern and are a necessary part of a growing, progressive economy in a safe, free world.

How do some of these projects start? A few examples, some of which you will

* Presented at the March 1954 meeting of the Southeast Section of the ECRC.

easily recognize and others which are merely work-a-day occurrences, will illustrate. One very unglamorous and purely commercial initiation of research occurred some years back. For many years laborers slaked quicklime in improvised wooden boxes. The resulting putty was very plastic and satisfactory. Then, an enterprising manufacturer conceived the idea that steel mortar boxes would save time and trouble and soon his sales promotion resulted in the use of the steel boxes by contractors. But something peculiar was happening to the putty when the steel boxes were used. It had lost its plasticity and the manufacturer of the lime was losing most of his customers. Survival dictated that an answer must be found for this unusual situation. His laboratory men and several consultants tackled the problem and after considerable "cut and try" experimentation discovered that the steel box grounded the batch and destroyed its plasticity. Thus, the simple expedient of insulating the steel box from the ground solved an immediate need. This was, however, not the end for the inquiring mind. From the simple necessity inherent in this case have grown a host of research projects involving the influence of potential on the micromeritics of lime. Much of this work has been fundamental and applied research projects have continued in this field, and many students in colleges have tackled facets of the same problem. A simple but imperative commercial need initiated the study, the unfolding of the phenomena interested others who saw applications of the same principle to other problems and needs.

Need Amplified By an Idea

With an eye to expanded markets for the products of his plant, a prominent industrialist whose product, celluloid, was gaining increasing applications, conceived the idea that it should be possible to produce a thin, transparent, tough sheet which could revolutionize the packaging industry. He had the packaging of cigarettes in mind. He told his research men that they might have a limited time and unlimited funds but that he wanted this product. The result was cellophane. You are all aware of the growth of this idea which originated from a need for greater sales. Many subsequent studies and experiments, both applied and fundamental, have gradually merged into the many ramifications of the plastics industry as we know it today. It would require many hours to relate the many projects and to assess the tremendous effort and the large expenditures of funds of which this infant industry has been the beneficiary. Nevertheless, most of these originated with a need amplified by an idea.

Many times a desire resting heavily upon the mind of a scholar or technician prompts the initial efforts to seek a solution. Would it not be possible to improve communications, said Morse, as he set about applying the new-found electrical current to a signalling device using a shorthand alphabet. Another scientist explored the possibilities of using mechanisms to fit equations to curves resulting from test data which baffled existing mathematical science or involved laborious effort and time. With the aid of funds from sources appreciating the new avenues which the solution of such mathematical approaches might open, he initiated the researches which after further applications of the idea and methods resulted in our great calculating machines. The desire to photograph fast moving objects resulted in the discovery of stroboscopic light and its correlative necessity, high-speed photography. Such discoveries always aid immeasurably in reassessing some of our older concepts and in improving our approach to the more rational solution of old problems already thought finished. There are too many of such fascinating episodes to do more than call your attention to these few at this time. They all follow a definite pattern. They all illustrate that a great desire or need, coupled with the activities of keen minds and with the exercise of tenacious courage

finally win out. Funds are always available wherever and whenever such ideas suggest the possibilities of application to an industry or to another important problem, the solution of which is momentarily slowed down because of gaps in our knowledge.

Galaxy of Researches

The gradual awakening to the necessity for a solution of many of our social and economic problems has prompted a galaxy of researches. Our business men are concerned with the reasons for certain human behaviors; they want to know how they can cope with organized groups; they wish to fathom the phenomenon of public acceptance to help their sales; and they need a solution to the great problem of expanded markets and higher purchasing power. While many people would not normally think of these projects as research, tremendous sums and untold effort have gone into studies seeking solutions. Again the need and the reward prompt action.

In the medical field the picture is just as thrilling. The desire to save lives and to relieve pain here plays a scientific and emotional role. The reward which comes from success in these endeavors is more than financial—it is soul satisfying. The many discoveries within the last fifty years have stimulated the medical profession and a host of scientific people to apply the newly available equipment and techniques to old problems. Vast sums have been made available in this field by foundations, individuals, public subscription, medical schools and manufacturers.

The saga of the small beginnings which were to be the initial spark to ignite the now important field of atomic fission is well known by now. The first experiments with high voltages by Van de Graf, the succeeding developments of the cyclotron were all prompted by a tacit refusal to believe that the atom was indestructible. Physicists had believed for some time that the nucleus of the atom possessed tremendous pent-up powers. Much of this work was done with funds supplied by sponsors who had faith in the men who dared. The atom was split. Nuclear power was found. But then came the great need; the need for national survival. Man's inhumanity to man demanded that this great discovery be turned into the channels of war. You know the rest; the atomic bomb. Only recently were we admonished to use this newly found power to harness all of the mechanisms which we already had. The development of tracers has changed many of our methods of experimentation in industry and medicine. When this power and the elements of its action finally finds its application in all of our old techniques, many of the hidden recesses of knowledge will stimulate even greater expansions of our ideas of this world of ours.

So much for a very brief and insufficient rehearsal of research, its initiation and corollary impacts producing extensions of research. What is the pattern by which research proceeds? It seems to me that the governing seed of all research is a *need*. This must be followed by the desire on the part of some person or persons to satisfy the need. In the initial stages of any new concept a great deal of "cigar-box" applied research is done. This is, of course, guided by all existing knowledge and techniques of which the researcher is conscious. In many cases any extensions of such studies must have commercial significance. This will provide funds. If the idea is broad enough it will set up a chain of researches which will dwarf the original objective in its importance.

Succession of Steps

It is desirable, I believe, to restate the succession of steps which usually are taken in any project and then to suggest the requirements for its successful consummation. When a need is discovered the first step should be to prepare a clear and a concise statement of the problem and its objectives—State the Problem.

This should be followed by a study of existing knowledge bearing on the problem—Review Existing Knowledge. Then comes the task of setting up the scope of the work to be done and the ends to be attained if possible—State An Hypothesis. Following this comes the experimentation; the ever-liquid approach as new phenomena or conditions appear; the gradual process of testing the hypothesis not only by the originators of the work, but also by colleagues who are interested. The publication of results and of probable conclusions or the success of the recommendations when applied by the sponsor will gradually build up acceptance. In the process many offshoot ideas will usually be developed, which in turn may stimulate other studies in another direction; or, the impassable barriers of the unknown will set the search in motion for more fundamental approaches to remove such barriers.

Research properly and honestly pursued is enervating, expensive and often frustrating. Research demands the proper number and talents of personnel who have faith, courage, and who refuse to be frustrated. It also requires funds in sufficient amount to do a thorough job. I should like to present an abbreviated and annotated statement of the requirements laid down by The Engineering Foundation to determine whether their support would be justified.

A. Title of Research
B. Object of Research
C. Background Information
D. Facilities and Personnel Available
E. Probable Cost of Research
F. Background of Person or Persons Making Request

In closing may I repeat these important words again—"Research is the price of survival."

Sections and Branches

The **Ohio Section** Annual Meeting was held at Ohio State University at Columbus, Ohio on May 1, 1954. R. S. Paffenbarger presided at the Morning Session which included talks by B. L. Stradley and G. B. Carson, both from Ohio State University, and a talk by B. R. Teare, Carnegie Institute of Technology. This was followed by a discussion led by H. E. Fritz on "Opportunity Unlimited." At a business luncheon, the following new officers were elected.

Chairman—K. F. Sibila
Vice Chairmen—E. C. Clark
N. R. Rimboi
Secretary—A. R. Weber.

YET Awards were presented and reports were made on YET activities and the ECPD Training Committee.

The Afternoon Session with G. L. Tuve presiding included talks by G. A. Delaney, General Motors Corporation and W. F. Powell, General Electric Company.

The **Michigan Section** held its Annual Meeting on May 8, 1954 at the University of Michigan.

The Morning Session consisted of individual conferences of six engineering branches.

The Afternoon Session included a Report from Council by W. P. Godfrey, University of Detroit, a Report from the ASEE Secretary, A. B. Bronwell, Northwestern University, and a discussion of Evaluation of Engineering Education with a Panel composed of G. G. Brown, University of Michigan, W. E. Stirton, Wayne University and J. D. Ryder, University of Illinois.

New officers elected at this meeting were:

Chairman—C. C. Sigerfoos
Vice Chairman—G. H. Howell
Secretary-Treasurer—C. Fanning
Rep. on Council—R. H. Schoonover.

How Should We Educate Civil Engineers?

By B. A. WHISLER

Head, Department of Civil Engineering, The Pennsylvania State University

In recent years the leaders in engineering education have been advocating changes in curricula which are now being put into effect in many colleges. These changes reflect the increasing preoccupation of these leaders with the scientific aspects of engineering education and are the result of the emphasis now placed upon research and development in the manufacturing industries. The changes proposed and now being put into effect may be appropriate for the fields of engineering where the graduates go largely to manufacturing industries, but for several reasons they should not be applied to civil engineering.

All engineering is a combination of art and science and is distinguished from the basic sciences by the application of those sciences to the problems of mankind. Since the separation of the other branches of engineering from civil engineering several decades ago, the scientific aspects of the other fields have become predominant while in civil engineering the art of engineering has remained as a very important factor. It is quite usual in the manufacturing industries to make decisions which are based almost exclusively upon exact scientific facts concerning the materials to be used and the results to be obtained. Such a decision is unusual in civil engineering, for rarely can the civil engineer avoid the facts that his materials are extremely variable and therefore very imperfectly understood, and that each of his problems involves the satisfaction of a multitude of conflicting public interests so that almost never does he finally complete a project which he believes to be the best solution from the purely abstract scientific viewpoint.

Employment of Civil Engineering Graduates

In making changes which are the same for all engineering curricula, the very important fact that civil engineering students are being trained for some phase of the construction industry is completely ignored. That civil engineering students do go to the construction industry can be shown by a detailed analysis of the type of employment accepted by civil engineering graduates. The experience of the Pennsylvania State University may be used as an illustration. Questionnaires voluntarily completed by civil engineering seniors at Penn State just before graduation have been analyzed to obtain the pertinent information. This analysis covers the period from February, 1948, through February, 1954, and is based upon replies from 64% of the total number of graduates.

The distribution of graduates based upon the type of employer is shown in Table I. It is apparent that these graduates enter widely divergent types of companies and that no one type predominates. A relatively small number, 8.2%, entered universities as graduate students or teachers, the only real outlet for civil engineers interested in research and development problems. About 1/4 of the graduates entered manufacturing industries.

No exact knowledge of the precise type of work which these men did immediately after graduation, nor what

TABLE I

DISTRIBUTION OF EMPLOYMENT BY TYPE OF EMPLOYER

Classification	%
Consulting engineers	13.5
U. S. Government agencies	9.6
State agencies	11.7
Municipalities	2.5
Public utilities	2.5
Railroads	8.9
Contractors	9.6
Fabrication and erection cos.	9.2
Basic steel manufacturing cos.	3.5
Manufacturing industries	10.6
Aircraft cos.	4.6
Oil cos.	4.9
Self-employed	0.7
Universities	8.2
	100.0

they are now doing, is available. It is possible, however, to classify the type of work in each job on the basis of knowledge of the employment practices of the companies and upon information obtained directly from many graduates after they have spent some time on the job. On this basis, the type of work done by these graduates immediately upon graduation has been classified in seven categories. The distribution in these classes is shown in Table II. It may be seen that nearly half of these students took positions in or directly allied with construction. As the operations and maintenance positions accepted by civil engineers in the manufacturing industries usually involve a considerable amount of construction and may be almost entirely construction, it is not unreasonable to include these positions with construction. This inclusion indicates that 80% of these students became involved with the construction industry to some extent.

TABLE II

DISTRIBUTION OF EMPLOYMENT BY JOB CLASSIFICATION

Classification	%
Construction	12.4
Design	7.1
Design-construction combination	34.7
Operation and maintenance	33.0
Sales	1.4
Geodetic surveying	3.2
Education and graduate studies	8.2
	100.0
Construction and design-const.	47.1
Construction, design-const. and operation	80.1

Another factor which has considerable significance is that civil engineering graduates are not employed in large numbers by single employers. This is indicated in Table III which shows the distribution of graduates by the number employed per employer. Eliminating those going to universities, 259 students were employed by 116 different employers and 1/4 of the students went to employers who have hired only one man from Penn State during these five and one half years. An analysis of the latter group shows that they are predominantly small organizations such as municipalities and consulting engineers or companies so far distant that their employment of Penn State engineers would occur only because of some special situation which would not be apt to recur.

TABLE III

DISTRIBUTION OF EMPLOYMENT BY NUMBER EMPLOYED PER EMPLOYER, NOT INCLUDING EDUCATION

No. Employed per Employer	% in Each Class
1	25.8
2	16.9
3	11.6
4	6.2
5	7.7
6	7.0
8	3.1
9	7.0
10	7.7
18	7.0
	100.0

These employment records indicate that civil engineering graduates are employed by a wide diversity of employers

with no one type predominating, but that nevertheless they are largely employed in some phase of the construction industry. This is not surprising as, almost by definition, civil engineering is the engineering of the construction industry. If civil engineering curricula were to emphasize the preparation of graduates for the fields of research and development, they would be entirely unrealistic.

In other fields of engineering the employer is depended upon to develop in the graduate engineer an understanding of the art of engineering and the applications of the basic scientific principles of engineering through formal or informal training courses. This can be expected because these employers are largely organizations of great size employing large numbers of graduate engineers each year. Smaller companies may obtain their engineers from the pool of young engineers developed by the large organizations. In civil engineering, however, the graduates go predominantly to smaller organizations which employ relatively few engineers each year and do not have the facilities for training programs. Therefore the undergraduate training program must be broader and must include more training in the art of engineering. The graduate civil engineer must be prepared to do a good productive job for his employer immediately upon reporting for work.

Requirements of a Civil Engineering Curriculum

Specifically, the current proposals for changes in engineering curricula take the form of requiring additional courses in higher mathematics and physics and other additions of this nature. Such changes are necessary for students who will later work in fields which require this specific background, but for the civil engineer such courses are of little significance. Because of the type of work he does, there are many other subjects of much more importance to the usual civil engineering graduate.

Upon entering the construction industry civil engineering students very quickly assume a degree of independent responsibility not reached by those in other fields for many years. It is not unusual, for example, for them to be supervising large construction projects a year or two after graduation. This is particularly true if they begin work with some organization, such as a state department of highways, which has been losing its older engineers and has been unable to replace them adequately. Such an organization must of necessity give a high degree of responsibility to its young engineers very early.

As a result of the early responsibility assumed by the young civil engineering graduate, he is soon placed in a position where he must be able to communicate accurately with his supervisor, both orally and in writing. He must be able to report accurately and concisely upon the progress of a job, the need for changes in design, the reason for having made field changes, and many other such matters. In college he should be well grounded in spoken English and more particularly in written English. With the present lack of emphasis on English at the high school level it is more important than ever at the college level. The present trend toward placing a greater and greater emphasis on higher mathematics and physics is requiring more credits for these subjects. This requires a reduction in credit for other courses. There is serious danger that the result will be a decrease in emphasis on the use of the English language.

The civil engineer, whether in the field of design, construction, or maintenance, deals with a much greater variety of materials than does any other engineer. In addition to the metals which are handled by others, he deals with extremely complex, variable, and poorly understood materials such as soils, portland cement concretes, and asphaltic concretes. Hardly an institution in the country covers these materials adequately at the undergrad-

uate level. There was once a time when the coverage was better, but in recent years the study of materials has been neglected in order that new subjects might be added to the curricula; subjects which only rarely would have direct application to the work of the practicing civil engineer.

Similar arguments could be made for the need for a greater study of labor relations, accounting, economics and other subjects. Most civil engineers could profit by such studies and would find them much more useful than the study of differential equations and atomic physics.

Quality of Civil Engineering Graduates

New curricula have been designed to train the engineering student of superior intelligence along lines even more specifically pointed toward research and development than those proposed for engineering curricula in general. The very best students are being recruited for these curricula. For the very superior student who is truly interested in such work as a lifetime occupation, this is an excellent development. There is the danger, however, that the glamour and prestige of such an elite curriculum will attract many who by temperament and interest should remain in a regular engineering curriculum in order to be better prepared to enter into normal engineering activities. Brilliant minds are needed in the traditional engineering jobs as well as in research and development.

It has become commonplace to think that the engineer in the construction industry need be only a person of average intelligence. This is anything but true. The civil engineer is responsible for the conception, design, and execution of the works of the construction industry, the largest industry in the country. In contrast with other fields of engineering where the products last only a few years at most, the civil engineer builds for decades, and in some cases for centuries in the future. The highest type of intelligence is needed for such work. The quality of man needed to supervise the construction of the San Francisco-Oakland Bay Bridge, the Hoover Dam, or the great works of the TVA certainly needs to be as high as for any other field of engineering. Yet few of these men need such advanced training in mathematics and physics as many of our leaders in education would now require. The few civil engineers in advanced design of a very special nature who do need such specialized education can best acquire it at the graduate level.

By the very nature of his work, the civil engineer on the average job is much more independent of others in the conception, design, and execution of his work than are other engineers. Certainly intelligence and broad vision are as necessary in all phases of the everyday construction project such as a new sewage or water treatment plant, a highway relocation, or a flood relief project as in the design of a new manufactured product or a machine for making it. The need for a broad education and a highly intelligent approach to the problem is just as great for the civil engineer concerned with the small project as it is for the civil engineer on the greatest project, and the need for a knowledge of advanced science is even less.

Engineering educators must make a special effort to guide to specialized curricula only those brilliant students who are particularly fitted for them. The highly intelligent students who should remain in the traditional civil engineering field must be shown that tremendous opportunities are awaiting him in civil engineering.

Modernization of Civil Engineering Curricula

One of the standard and often repeated criticisms of engineering curricula is that they have not changed with the times and therefore are completely out of date. This criticism is particularly applied to civil engineering. A superficial examination of the curricula might give credence

to this belief, but to those who study the matter thoroughly, its falseness is obvious. Just because a subject entitled "Reinforced Concrete" appeared in a 1910 curriculum and still appears in present curricula is no evidence whatsoever that the curriculum is not up to date. It merely reflects the fact that reinforced concrete is now and long has been the most important single construction material. The content of such a course as actually taught is the critical point in the determination of whether or not a curriculum is up to date. If the course is taught as it was in 1910 it is obviously out of date, but if the course includes the significant modern developments in theory and practice, as is the usual case, it is as up to date as it would be with a new name.

Surveying, which is virtually the oldest and most universal of civil engineering subjects, has been a part of civil engineering training from the time of the first curriculum to the present day. It reaches back to the beginning of written history, but the continual addition of material concerning new methods and equipment such as photogrammetry and electronic measuring techniques has kept surveying courses completely up to date.

As significant new developments have taken place in the field of civil engineering, some have become sufficiently important to justify inclusion in curricula as separate courses. Improvements in the understanding of the engineering properties of soils and of the phenomena of hydrology have resulted in the inclusion of separate courses on these subjects in many curricula. Such courses include the advanced training in the sciences which is necessary for an understanding of these new developments. For example, an elementary knowledge of statistics is necessary for the proper understanding of hydrological problems. Most schools are continually revising and improving their curricula in this way.

Decision of Major Importance

Educators in the field of civil engineering are faced with a decision of major importance. On one hand we can follow the present trend toward increasing the concentration of undergraduate training in mathematics and physics. Our graduates will become less trained engineers and more trained physicists. On the other hand we can consider the actual engineering work our graduates do and concentrate our efforts upon the improvement of a program of broad training in both technical and non-technical subjects designed to provide a solid foundation for a lifetime of work in civil engineering. In this case we will depend upon graduate study and upon the training of long experience for the development of our specialists. If we believe in a broad basic education at the undergraduate level for civil engineering students of all levels of mental ability, we must speak up now, while we still have the opportunity.

ANNUAL MEETING

June 20-24, 1955

Pennsylvania State University
State College, Pa.

Report of the ASEE Manpower Committee*

Current Demand for Engineering Graduates

By June 3, the Engineering Manpower Commission had tabulated returns from the 1954 Survey of Demand for Engineering Graduates, initiated by the Engineers Joint Council's Special Surveys Committee, covering almost exactly the same number of companies and governmental agencies as in the 1953 survey. These organizations, moreover, had in their employ on January 1, 1953 94% of the same number of engineers as did the 1953 survey sample and, with few exceptions, there was also close correspondence between the coverage for the two years within individual industries and in government. It has been concluded, therefore, that the 1954 data, adjusted for the 6% total difference in coverage as measured by the number of engineering graduates in the employ of these organizations, may be compared directly with the 1953 data in order to determine significant differences in the demand between the two years.

Table I, attached, presents summarized data from these surveys for industry and government combined. In general, industry accounts for about 85% and government for about 15% of the sample. 1952 data from the 1953 survey have been included to bring out the general trend. Current needs have been expressed in terms of the net accessions expected and required by these organizations since that figure is the resultant of the employment of both current and experienced graduates and of returns from military service as related to the losses of graduates from all causes. In the final analysis, such accessions must come from new graduates or graduates entering employment from military service.

In this table, line 5 for 1953 and line 3 for 1954, as adjusted, namely, the number of graduates in the employ of these organizations on January 1, 1953, have been made to match. Proceeding from this base, line 6, 1953, expected net accessions, is comparable to line 4, 1954 adjusted, net accessions realized in the matched sample. Comparison of line 6, 1954 adjusted, with the corresponding figure for 1953, shows a decrease in expected net accessions during the two years of about 21%. Undoubtedly this constitutes recognition of the fact that the graduating class in 1954 had decreased in about that same ratio. Interestingly enough, however, the decrease in required net accessions is also about 21%. In both years expected net accessions are about 60% of those required.

Two general conclusions may be drawn on the basis of these samples. First, the decline in business activity and defense orders in 1954 has led to a decrease in the requirement for engineering graduates of about 20%. Second, with the relatively small classes graduating at this time, despite this decrease, there is still substantial unfilled demand.

Actually, in total employment, these samples covered 8%, plus or minus, of total non-agricultural employment in the country and about 25% of the employed engineering graduates. If any attempt were to be made to estimate the total demand from the samples, the figures shown might be multiplied by four, assuming that current demand would be proportionable to the total number of graduates employed. It is probable, however, that the responding companies

* Presented at the Annual Meeting of ASEE, University of Illinois, June 14, 1954.

TABLE I

DEMAND FOR ENGINEERING GRADUATES

Surveys of Engineers Joint Council Committee

	1953	1954	
		Actual	Adjusted
1. Number of organizations	376	377	—
2. Total employment	4,151,210	3,279,086	3,480,000
3. Total engineering graduates, January 1 previous year	116,653	117,821	125,100
4. Total net accessions*	8,433	6,508	6,900
5. Total graduates, January 1 current year	125,086	124,329	132,000
6. Total net accessions			
Expected*	6,692	5,254	5,560
Required	11,386	8,449	8,950
7. Total graduates, December 31	131,778	129,581	137,560

* Employment from current and earlier classes, plus returns from military leave, minus losses from all causes; slightly adjusted to balance.

have a relatively higher current demand than those who did not do so and this process might result in unduly high estimates. There seems little doubt, however, that actual demand is greater than the current supply.

Supply of Engineering Graduates

Table II presents data concerning the supply of such graduates for the same two years only. The 1953 data here are unchanged from the report of a year ago. Those for 1954 are only slightly altered as the result of new figures for the ROTC. Both tables omit any figures regarding entrants into and graduates from post-graduate work. Since, normally, those numbers might offset one another, there is some evidence that currently the numbers of graduates completing *full-time* graduate work exceed those entering it. If, however, there is any further supply from this source at least an equivalent number of men would be absorbed in education itself.

There are excellent estimates from Dr. Henry Armsby of the U. S. Office of Education concerning the numbers of graduates expected in 1955 (23,000),

TABLE II

SUPPLY OF ENGINEERING GRADUATES, 1953 AND 1954

	1953	1954
1. Graduates	24,000	19,000
2. ROTC commissions	4,500	6,000
3. Draft eligible and other reserves (a)	7,200	7,000
4. Net for industry and civilian government (b)	12,300	6,000
5. Returnees-Recent graduates (c)	14,000	12,000
6. Totals for industry, etc.	26,300	18,000

(a) 1953—Engineering Manpower Commission Survey.
1954—Remainder after deduction of ROTC, veterans, and 4 F.

(b) 1953–Derived directly from Lines 2 and 3; about ⅔ pre-Korea veterans and ⅓ 4 F.
1954—4 F (⅓ of non-ROTC and non-veterans) + veterans (15% of class).

(c) ROTC and draft eligibles 2 years previously.

1956 (30,000) and 1957 (34,000). No attempt has been made, however, to estimate the remaining figures in this table because of uncertainties in military requirements.

General Considerations

In fact, it is apparent that the most important elements in this problem now can hardly be reduced to numbers. Underlying all of them are the critical international situation and the demands it may create through need for a massive build-up in weapons to maintain the balance between the Communist and free nations, or through full-scale war itself. In this connection, we are reminded that Russia is estimated to have graduated 43,000 engineers in 1953 and possibly 60,000 graduates of institutions similar to our technical institutes which had only 11,000 graduates.

More specifically, the Department of Defense has been unwilling to estimate the number of ROTC commissions in the next few years, since it will be dependent on both military forces on active duty and the reserve program now under intensive study. Although draft calls currently are at the low level of 18,000 per month, they are expected to rise to 23,000 during the last six months of 1954. With the expiration, however, of one million enlistments during the next few months and the sharp drop in the reenlistment rate, the increase in Selective Service calls may have to be far greater even if the total military forces are not increased.

From the point of view of the most effective possible use of a country's engineering and scientific manpower, there have been several disturbing elements in the situation:

a. The position of the Director of Selective Service that there should be no exemptions for physically fit young men resulting in numerous withdrawals of occupational deferments and those for graduate students without full recognition of individual qualifications and needs. Occupational deferments, about 40% of which are for engineers, are now below 20,000 and have been decreasing several hundred per month.
b. The present expectation that the training and experience requirements for MOS classification in the scientific and professional personnel group will be raised, resulting in the increased malutilization of engineers and scientists called to active duty.
c. The building up of a huge reserve through the operation of the Universal Military Training and Service Act, subject solely to call by the Department of Defense in the event of war.

Recently there have been definite indications that the administration is coming to realize more fully the nature of this problem. This was manifested in the recommendation of the Appley Committee on Manpower Resources for National Security released in January that both immediate and selectively callable reserves be established, with the former relatively limited in size and with call up of the latter subject to civilian control on a selective basis. In six or seven large industrial states, the Selective Service system has set up advisory committees to assist the Selective Service Boards in considering applications for deferment of professional personnel. More generally, there seems to be increasing recognition that deferment policy must be geared not solely to the present cold war situation but to the necessities which may be imposed by a greater future emergency. It is our conviction that the Engineering and Scientific Manpower Commissions and their staffs have made significant contributions to the development of such a point of view.

D. S. BRIDGMAN,
Chairman, ECAC Manpower Committee

The Technical Institute and Some of Its Problems*

By C. S. JONES

President, Academy of Aeronautics

At the Winter meeting of the Technical Institute Division, one of the speakers, President of a thriving engineering research concern, stated that until he started to assemble the material for his talk about graduates of technical institutes he himself had not realized the number and importance of such graduates employed by his own organization, and he chided us for failing to keep industry informed as to their capabilities.

Dean Freund, in his paper "The Technician and Engineer," presented at the Florida meeting, expressed similar sentiments and closed his remarks with the suggestion that the Technical Institute Division devote its time educating the engineering profession. Consequently, we decided to devote our main effort toward acquainting prospective students, parents, engineers, and employers with our activities. This report is in line with this policy.

To implement such a policy it seems wise to review what has been done, to explain the improvements we have been attempting to make, to analyze the reasons why there has been so much lack of information, or even mis-information, and why it has been so difficult for the Technical Institute to put over their story.

The Technical Institutes have a long and honorable history. Mechanics Institute was founded in 1785 in New York, and several other institutions are over 100 years old. True, these early schools were intended to upgrade and provide technical instruction to supplement the apprentice training largely prevalent at that time. It was not until 1931 when the Spahr Wickenden Report was published that much attention was given in higher educational circles to such institutions. This report, which proved conclusively that approximately three trained technicians or semi-professionals should be employed for every engineer, was widely read and discussed, though no immediate action was taken.

Starting at the turn of the century a series of highly technical inventions changed the industrial, commercial and military habits of the nation. Gas and diesel engines, the airplane, radio, television, electronics and others made sweeping changes, requiring the services of a new kind of personnel; the modern technician. Many of these inventions would have developed much more slowly if it had not been for their adaptation to military use, and the fact that in this period we engaged in two world wars, where money and brains were made available in unlimited quantities to perfect them.

Take the airplane. The Army ordered its first plane in 1908, and by 1914 had a total of only fourteen planes, a handful of pilots and there were only two aircraft companies. By 1944, only 30 years later, the aircraft industry produced 20 billion dollars worth of aircraft and became the largest business the world has ever known. In 1914 the airplane

* Presented at the Annual Meeting of ASEE, University of Illinois, June 14, 1954.

was a simple mechanism with ordinary gasoline engine, stick and wire construction, almost no instruments, which any ordinary mechanic could keep in operating condition. Contrast this with the modern aircraft with its myriad of instruments, pressurized cabins, electrically controlled propellors, retractible landing gears and hundreds of highly technical gadgets and you realize that the ordinary mechanic will no longer do. It takes a highly skilled, highly trained technician with tremendous know how. Or take a little thing like the modern bombsight that electro-mechanical brain which almost instantly computes speed, drift, windage, and altitude to the target, and just prior to the release of the bomb, actually flys the aircraft over its target. It is easy to understand why such an instrument needs an expert to keep it in operation, and not even a trained engineer could do it without technical know how. And so, in all branches of the service—the horse has been replaced by the tank and jeep, the gun fire on battleships is done electronically, even the typewriter is electrically operated. With the outbreak of World War II when much of this mechanization had been perfected thousands of men were needed to keep the equipment running and so the military enlisted support of the schools, first the technical institute (we started our program in 1938) and later colleges and universities.

Mutual Respect Established

I well remember when the representatives of six large Eastern Colleges and universities sat in my office, sent there by the Air Force, to learn how we, a lowly technical school, trained technicians so capable in such a short time. The Department of Education in the states of New Jersey and New York, who in the early days took a dim view of our activities, actually took over our institutions during the war which we rented back and operated for them in order that we, a proprietory school, could utilize government funds for the necessary training program, and I can safely say that this close contact and understanding did much to establish a mutual respect which still exists. This entire military program did much to strengthen our own curricula and in many colleges gave the engineers an insight into the technical training program.

Thus in 1944, when the Engineers' council for Professional Development appointed a sub-committee with Dean H. P. Hammond of Penn State as Chairman, there was not much resistance to setting up the accrediting system for technical institutes which is now in force and which last year approved curricula in 26 such institutes. I have always felt that the appointment of Dean Hammond was a stroke of genius and extremely fortunate for our schools, for here was a man widely respected in his field, who had made a true analysis of the situation, appreciated the value of the technical institute training, and had the courage and initiative to act. At the American Society for Engineering Education meeting in Austin I had breakfast with him and started to thank him for what I considered his effective efforts in our behalf. He quickly stopped me explaining that he was not doing it because he particularly liked the technical institutes or wanted to help them. Rather he felt he was helping the colleges. He said that the facilities of the engineering colleges were overcrowded, that they could not turn out the needed number of engineering graduates, that many men in these colleges were incapable of becoming professional engineers and were consequently wasting time and facilities and probably should be in a technical institute. He finally stated that he figured an engineer who did not utilize the services of technicians to relieve him of a lot of detailed work that the technician could do just as well, or better, was not doing an efficient job, and probably should not be an engineer anyway. If more of the engineering fraternity had this philoso-

phy and breadth of viewpoint we would not still be arguing as to whether or not our graduates could properly be called "engineering technicians" and that an "Associate Degree" is the proper award for our graduates.

Shortly after the establishment of this accrediting system, the Technical Institute Division of the American Society for Engineering Education was formed and during the last six or seven years has grown into a healthy and aggressive branch of the organization.

At about the same time a group of proprietory schools organized a National Council of Technical Schools, adopted a code of ethics, thus adding another stabilizing influence. Spurred on by these organizations the schools themselves have made great strides in improving and strengthening their curricula, their faculty and their facilities. While the minimum accredited curriculum is 960 contact hours over a period of one academic year, most of these schools offer courses far in excess of this. It must be remembered that most technical institutes operate six to eight hours per day, five days per week over a 44 to 48 week year, with few vacations. Entrance requirements have been raised and only bona-fide high school graduates are admitted. Most institutes now require an applicant to pass well conceived entrance tests and have found that this policy has paid real dividends. Courses in advanced mathematics, physics, chemistry and the like are now common practice and are certainly at the level of higher education. Because of the great amount of technical work covered in a relatively short time, the teaching of English and the Humanities has been neglected, but even in these fields an effort is being made to include a reasonable amount of instruction. Many institutions have embarked in sizable research programs, and placement and counselling have greatly improved.

While I am on this subject I would like to say that we are far from happy at the preparation of the average high school graduate in such basic subjects as English, Mathematics, Reading and Spelling. I wonder if it would not be a worthwhile project of the American Society for Engineering Education to encourage the high schools to strengthen these subjects, even at the expense of the highly controversial extra curriculum activities, so when a boy enters our institutions we won't have to waste so much time teaching him the things he should have learned in high school.

Functions of the Modern Technical Institute

So much for what has been accomplished. Before discussing some of our problems I would like to include for the record a brief summary of the actual functions of the modern technical institute, even though I suspect they are well known to most of you. The technical institute fills the gap between high school and college. Its curricula are of a technological nature and lie in the post-high school area. They differ in content and purpose from those of the vocational schools on one hand and from those of the engineering college on the other. Their purpose is to prepare individuals for various technical positions in the field of engineering, but more limited in scope than required of the person preparing for a degree as professional engineer. The engineer plans—the technician makes and does. The engineer creates the project—the technician operates. Programs of instruction are briefer and more technical in content than professional curricula though they are both concerned with the same general fields of Industry and Engineering.

Courses accredited by the Engineers' Council for Professional Development include aeronautics, air conditioning, refrigeration, building construction, diesel and steam engines, drafting and design, electronics, industrial chemistry, machine design, photographic technology, radio and television. The following chart indicates the number of enrollees and the

ENROLLMENTS IN TECHNICAL INSTITUTES—10TH ANNUAL SURVEY

Compiled by Dr. Leo Smith, *Rochester Institute of Technology*

Type of Institution	No. of Schools	Enrollment 1953-1954			Enrollment 1952-1953		
		Day	Evening and Part Time	Total	Day	Evening and Part Time	Total
Federal					—	1,670	1,670
State and Municipal	20	10,192	7,195	18,107	9,239	8,902	18,141
Privately Endowed	11	2,780	7,798	10,578	2,506	8,983	11,489
Ext. Div. of College and Universities	11	2,993	9,774	12,767	2,045	10,885	12,930
Proprietory	19	5,800	3,421	9,221	5,038	3,119	8,157
YMCA Schools	2	51	504	555	12	338	350
Total	63	21,816	29,412	51,228	18,840	33,897	52,737

different types of ownership and operation.

Though these figures are impressive and represent a steady growth, they are a far cry from the suggested 3 to 1 ratio when compared with the 160,000 enrolled in engineering colleges. Several hundred thousand would be more in line.

What then has held up this obviously important branch of education and what are the prospects for the future. Probably the biggest deterrent has been the attitude of the professional engineer in many cases unintentional. Frequently, he has considered the technical institute as a trade or vocational school—in many cases a sort of a racket trying to sell an artesian as an engineer. When as in the '30's there was an excess of engineers it is understandable why he should resent any incroachment in his field and why trained engineers had to do work below their true capabilities. The engineering employment manager, himself often a graduate engineer, was guided by the same thinking so it was difficult for the technical institute to get a hearing and for its graduates to get a job commensurate with his ability and training.

In the early days of our own school I spent over half my time begging my friends in the aircraft industry to use our graduates—placing one here and one there—largely on a friendship basis. And then I remember the day when the Chief Engineer of one of our big companies 'phoned to say he would hire our entire graduating design class, largely because engineers were getting short in supply and he had to have somebody. And then I think of the hundreds of our graduates hired by this same company since that time and the general acceptance of them by the aircraft industry, no longer because they cannot get anyone else, but because they do the job. And the contrast today when some months before graduation representatives of industry come to our door to interview our students, many of these representatives being our own graduates an astute bit of salesmanship when competition is as great as it is and when each graduate has an offer of several positions.

Enginering Graduate and Technician Supplement Each Other

And so this road block is being gradually broken down, but we will not reach our goal until engineers in general come to the same conclusion that Dean Hammond did years ago, namely, that there is a place for both the engineering graduate and the technician, that they supple-

ment each other and that their effective joint effort as a team is essential.

When this happens the situation will take care of itself and we can see signs of progress. States, counties and municipalities are establishing technical institutes as evidenced by the present ambitious program in New York State. Community and Junior Colleges are turning more to technical curricula. The military still maintains a vast system of technological education.

In spite of these encouraging signs, we still have a long way to go if we are to meet the 3–1 ratio of technicians to engineers suggested by the Spahr Wickenden report, mentioned earlier. This report is over 20 years old, and should be brought up to date, or a new one made. It is believed this is of sufficient importance to justify a grant from one of the foundations.

Figures from abroad indicate the United States is lagging in technological training. England has twice the numbers, while figures from Russia report several hundred thousands in technical schools.

From the military viewpoint the great advantage of the United States over its potential enemies is its engineering genius, technical know how, and production ability. The fact that we enjoy a far higher standard of living than any other nation is largely attributable to the same reasons. If we are to maintain this superiority, either in war or peace, a sound, coordinated and expanding system of engineering and technical education is a prime necessity.

Sections and Branches

The **National Capital Area Section** of the American Society for Engineering Education held its Annual Meeting 8 May 1954 at McMahon Hall of The Catholic University of America.

Mr. Henry H. Armsby, section member on the General Council, made a complete report of the Council's activities and submitted a written copy to the Secretary for the section's files.

Vice-Chairman Michalowicz then introduced Messrs. R. H. Buescher and E. K. Von Fange, both of the General Electric Company's Creative Engineering Program. Mr. Von Fange spoke on "Creativeness in an Engineering Program." This was followed by a "brainstorm" session which obtained about fifty ideas to bring Creativity into an engineering education in specific courses by the audience. A provocative and stimulating discussion followed. It was recommended that other sections have meetings like this one.

Professor John L. Artley, chairman of the section's committee on Young Engineering Teachers, presided at the afternoon session. He introduced the winners of the YET paper contest for the section: First Place: Robert M. Adams; Second Place: a tie between A. Lawrence Guess and Haaren A. Miklofsky. Chairman Walther congratulated the winners and presented them with certificates and cash prizes from the section. Professor Adams read his paper entitled "Value Concepts of Engineering Education."

With Chairman Walther presiding at the final business session, the Resolutions Committee presented its report. Finally the Nominations Committee (L. K. Downing, Chairman; L. E. Otts, Jr.; H. P. Gallogly, D. E. Howard, R. Goetzenberger) presented their slate which was unanimously accepted. The new officers for 1954–55 are:

Chairman—J. C. Michalowicz
Vice-Chairman—R. H. Roy
Secretary-Treasurer—D. E. Howard
Representative on General Council—
H. H. Armsby.

THE T-SQUARE PAGE

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DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

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Building Blocks of Engineering Education

By A. S. LEVENS

Professor, Division of Engineering Design, University of California

A summary of a preliminary report by the ASEE Committee was presented in the November 1953 issue of the JOURNAL OF ENGINEERING EDUCATION. This summary points out the increasing importance of the basic sciences in engineering progress. As examples of the increased importance the committee cites developments in electronics; problems related to structures; research in heat transfer; fluid mechanics; jet and rocket propulsion; metallurgy; etc.

The committee stresses the importance of the basic sciences—mathematics, physics, and chemistry—in engineering curricula. It suggests that mathematics through ordinary differential equations seems close to a minimum essential for all engineers. It recommends greater emphasis upon basic science in engineering education. The committee recognizes nine important background sciences in engineering. These are statics; dynamics; strength of materials; fluid flow; thermodynamics; electrical circuits; fields and electronics; heat transfer; engineering materials; and physical metallurgy. The committee believes "that all of these studies should be represented in curricula that train engineers for service in research, development or design, and that probably seven should be integrated into every curriculum that is represented as education for engineers."

Many engineering educators would agree with the committee's view of the importance of the basic sciences and the recognition of the "background" sciences in engineering. Personally, I do not quarrel with what has been included but am quite disturbed over the omission of a very important field—graphics. Should not the study of graphics be represented in all engineering curricula? In my opinion our engineering students will not be adequately prepared to meet the technological challenges of today nor of the future without (a) thorough knowledge and use of the fundamentals of projection; (b) reasonably proficiency in graphical representation—working drawings, pictorial sketches, etc.; (c) knowledge and use of graphical calculus, introductory phases of nomography, and graphical methods of computation.

Important Role

Graphics has played and continues to play a very important role in industrial progress. It is an essential part of the engineers preparation. We must continue to strengthen our students in engineering by providing them with many opportunities to make fuller use of mathematics, physics, chemistry and graphics. Our students should become aware of the fact that nearly all solutions of engineering

problems are at best close approximations; that judicious use of various methods may be advantageous. In some cases the mathematical tool is best, in others the graphical tool, in still others a combination of the two methods is indicated, and in certain instances a combination of graphical, mathematical, numerical, and mechanical methods is best suited to the analysis and solution of phases of an engineering problem. Certainly it would be considered poor engineering to insist upon a mathematical solution when, for example, a simpler graphical solution is available. We have become, by training, accustomed to the use of algebraic methods in solving problems, and we have developed a "reverence" for the reliability of answers that are obtained by such methods. Many students believe that "correct" answers to problems obtained by the manipulation of equations are exact. This may be true for "ideal" problems. Often problems are concerned with time, temperature, pressure, length, etc., quantities that can be measured only approximately. The reading of a thermometer, for example, can only be as accurate as, among other things, the graduated scale (graphical) and the visual acuity of the observer. This is also true of lengths, whose measurement again depends upon a graphical scale; or of pressure, whose measurements depend upon a gage mechanism and a scale for reading numbers; or of voltages, currents, and many other quantities which are measured by devices that indicate values on a scale which is read by an individual. The *data are graphical* in nature. Certainly many problems that inherently are based on graphical data can be solved by graphical methods with sufficient accuracy. The fact that we use numbers, obtained by reading various scales, in a mathematical solution of the problem, does not by any stretch of the imagination, make such a solution more accurate than a graphical solution.

We know that thorough training in mathematics is essential to sound engineering and scientific training. It is, however, important for students not to get a warped view; for their training to lead to the intelligent use of several methods, and, it is hoped, to the development of good judgment in the choice of methods. Surely the economical aspects have a decided bearing upon the choice of the methods employed.

Our engineering curricula must also provide time for adequate preparation in the field of graphics—a field which is definitely at the college level—not for the training of draftsmen *per se* but rather for the development of engineering students who are preparing for the engineering profession.

Suggestions for Adequate Training

The present day need and future needs for well-prepared engineers—men who can cope with problems that will arise in new fields, men who thoroughly understand basic principles, men who are capable of a high degree of "imagineering"—is so vital that our position as leaders both in a free society and in technology may well be at stake. Good training in graphics can contribute significantly to the development of the engineer of the future. To provide for such training, I offer a few suggestions:

1. We should continue to do a good job in the basic graphics courses, but let us not hesitate to revitalize course content. We should not include such trivia as pencil sharpening, lettering, simple geometric constructions, etc. These skills should be prerequisite to a college level course. Granted that some engineering schools do not require high school drawing for admission, it is certainly in order to require the student to take a noncredit course which will provide for training in the above-mentioned skills. We can and should carefully review course content with a view toward strengthening the student's grasp of basic principles, and yet not sacrifice the goal of attaining proficiency in technique. We can pay more attention to the use of freehand sketching

and the use of time-saving methods by eliminating needless repetition of duplicate details. By making judicious use of freehand sketching, the elimination of non-essentials and the simplification of delineation, actual drawing time may be reduced considerably. Such time-saving measures coupled with pre-engineering drawing preparation would permit us to introduce elementary phases of advanced graphics —graphical calculus, nomography, and graphical methods of computation—*in our basic courses.*

2. We should participate in research projects. Here may be found excellent opportunities to demonstrate the effective use of graphical methods. As a result, classwork can be enlivened by citing cases where graphics proved invaluable.

3. We should make every effort to work closely with our colleagues who teach other courses, such as mathematics, mechanics, strength of materials, design, etc. We can correlate graphics training with the work in these fields. This is very important in order to provide for continuous use of graphics throughout the engineering program.

4. Some schools should offer advanced graphics courses—at the senior and graduate level. The fields of nomography and graphics computations, including the solution of differential equations, afford many opportunities for advanced work.

5. We should initiate or assist both in the formulation and implementation of graphics courses that would contribute considerably to the preparation of high school mathematics and science teachers. This is quite important if we are to prepare a new group of engineering students who will come to us with some appreciation of graphical methods and their importance both in engineering and science.

The implementation of the above suggestions means that we must encourage bright young instructors to carry such programs forward. It is incumbent upon us to make every effort to motivate the interests and arouse the enthusiasm of such young men for active participation in the fascinating field of graphics. Instructors in fields other than graphics should be invited to participate in the teaching of graphics so that the carry-over into other fields will be more efficient.

We shall have to share our progress and work together much more closely than we have in the past if we are to continue to grow and keep pace with the current and future needs in engineering education.

Sections and Branches

The **Middle Atlantic Section** of the ASEE held its Spring Meeting, May 8, 1954, at Lafayette College, Easton, Pennsylvania.

The General Morning Session was addressed by Dr. A. C. Monteith, Vice-President in charge of engineering at Westinghouse Electric Corporation. The topic of his talk was "Professional Development—A Mutual Responsibility."

After a short business meeting and luncheon, the afternoon sessions were started. The program consisted of five group meetings with the following topics: (a) Orientation and Training of Engineers by Industry; (b) Teaching Thermodynamics to Engineers; (c) Improving Students' Report Writing; (d) Should Mathematics and Physics be Taught as a Combined Course; (e) Professional Development of the Young Engineer.

Teaching Tips

Thwarting the Two-Day Term Report

By J. D. THOMAS

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The only justification for a term report in the English (or, presumably, any other) department is that it is the outward evidence of an educationally useful process that really does require an extended period for collection of material, for organization of thought, and for composition and revision. When the paper is huddled together by a student in the last week of the term, no one profits. Either the student is trying to delude the instructor—and perhaps himself as well—by offering a few frantic hours as the work proper to a term project; or he is stealing time from all his other courses during the critical pre-examination period. Each of these alternatives is educationally vicious, and they are not even mutually exclusive! We all know the refrain: "I'm sorry, but I just can't do . . . , because I have to write my term paper for Professor . . ."

Student behavior being a corollary of general human nature, there is just one way to prevent the two-day term report, and that is to make certain that a due proportion of every week of the assigned period actually is spent on preparation of the paper. The rule must be inflexible: only one week's work may be performed in any week. Allow a single deviation from this pattern, and you will be confronted with a half-dozen valid excuses from every dozen students. It is amazing how few grandfathers have funerals when it is known that the nature of an excuse makes no difference, in the sense that only the work of a single week may be done during the following week. In rare cases of extended illness and the like (they really are rare among people of college age), the instructor naturally will use his judgment as to how much the partial report is worth, but he still must permit only one week's work for each active week; after all, apart from any other considerations, that is only fair to the student and to his other instructors.

I present the following directions exactly as I distribute them to my students in a course offered primarily for sophomore science and engineering majors. Although in the first instance they were designed for the purpose indicated by the title of this note, I wish to point out that they obviate another great difficulty with term reports. If a student hands in a paper that is "all wrong," possibly not even on an assigned topic, there is not much that can be done about it at the end of the term, as criticism at that time practically is wasted. But if week by week every stage of the paper is reviewed by the instructor (each part is of course promptly returned, with marginal notes), it is impossible for students to go completely astray except by willful refusal to heed criticisms. I should like to point out, also, that the distribution of time indicated below allows a reasonably long period for the gathering of material and for outlining. Every instructor knows by experience that the average student thinks he can begin writing a long report almost before he has chosen a subject, and that this kind of haste is a prime cause of academic waste.

Colleagues are heartily welcome to copy

or adapt these directions in any way that may be serviceable in local situations.

Instructions for Long Paper

The purpose of this project is to help you learn a good method of preparing, writing, and documenting an investigative paper over an extended period. Preserve this sheet, and note on it the instructor's specific assignment of topic and any special directions given in class from time to time.

You should understand from the outset, and bear in mind at all times, that the PROCESS of investigation, planning, and composition is the whole point of the assignments, and that you will be judged by your success in following the specified sequence.

If *for any reason* you can not (or do not) perform the assignment of a given week, that assignment is automatically deferred to the following week and all subsequent assignments are likewise deferred one week. (It is not fair to you or the instructor to allow several weeks' work to be performed and submitted in one week, and it is also not fair to your other courses to permit the work of English 220 to cumulate.) Since only eleven weeks are available for the ten weekly assignments, the result of falling behind two weeks or longer would be that one or more of the important final assignments would never be written. If, however, you have a legitimate excuse for getting more than one week behind schedule, you may submit a full explanation in business-letter form. The instructor will take such statements into account, along with the work actually performed, in determining your grade for the course.

Assignments are due at the beginning of the class hour on Thursday of each week. In case of valid excuse (not mere whim), they will be taken as late papers on Friday or Saturday of the same week (*except* during Dead Week). The reason for the lateness of any paper submitted on Friday or Saturday instead of Thursday must be noted below the endorsement.

Be sure you understand that: (1) *under no circumstances will two assignments be accepted in one calendar week;* (2) *no assignments may be skipped;* (3) *nothing will be received during Dead Week.*

SCHEDULE

Week 1 —Submission of (at least) two possible topics.

Week 2 —Final choice of topic, with statement of the problem and tentative plan of attack.

Week 3 —Tentative bibliography in form explained and illustrated in textbook; OR account of personal interviews.

Week 4 —Thesis sentence.

Week 5 —Thesis sentence (revised as necessary) plus main topics (only) of sentence outline.

Week 6 —Full sentence outline.

Week 7—Sample section ending about 500 words *beyond* first footnote), with footnotes in form explained and illustrated in textbook.

Week 8 —Remainder of first half of paper, with footnotes (in form indicated for Week 7).

Week 9 —Second half of paper, with footnotes (in form indicated for Week 7).

Week 10—Outline (revised as necessary), complete paper (with corrections), and full bibliography (in form explained and illustrated in textbook).

IMPORTANT NOTE: If properly carried out, each of the ten assignments requires about the same amount of work. Week 4, for example, though in form only one sentence, represents the hardest and most important act of analysis of the entire series of assignments. If you dash off a sentence without long preparation and serious thought, you will later find that you are trying to construct a building on a crumbling foundation. DO A WEEK'S WORK EACH WEEK.

Engineering Graduate Placement Test Research

By A. PEMBERTON JOHNSON

Project Director, Educational Testing Service

On April 26, 1954, representatives of five leading employers of engineering college graduates met with representatives of ETS's Personality Research Division to make detailed plans for a cooperative industry-sponsored research program aimed at the development of placement tests for engineering college graduates. This research is an outgrowth of inquiries made to ETS about three years ago by the Committee on Student Selection and Guidance of the American Society for Engineering Education. A research plan has been developed with the assistance and encouragement of their Committee and of the Relations with Industry Division of the American Society for Enginering Education.

The cooperating employers are: The Bell System, The Detroit Edison Company, the B. F. Goodrich Company, the IBM Corporation, and the Westinghouse Electric Corporation. Dr. David R. Saunders of ETS is director of this research project.

It is anticipated that within several years the placement tests, developed through this research, may supplement the experience and judgment of skilled interviewers and become adjuncts to improved engineering manpower utilization, by aiding in the early placement of each newly-hired graduate in an area of work *through* which he might reach his maximum potential for the company and for himself. Examples of some important areas of work which may be studied are: applied research; design; development; day-to-day engineering operations like production, construction, or utility operations; and technical sales. The marked economic and social advantages to employers, individual graduates, and the nation at large from improvement in the utilization of each year's engineering graduates are clear.

Plans for the research involve: (1) careful determination and description of the work functions carried out by key-groups of five to seven year experienced engineers who are employed in important areas of work in each of the participating companies; (2) the development and tryout of appropriate tests designed to reflect, to the greatest possible extent, differences in intellectual and personal qualities between successful engineers in the key-groups; (3) the development from the research findings of tests especially promising for use with newly-hired engineering graduates. As early as seems practicable, testing of newly-hired engineering graduates will begin also, utilizing, to the maximum extent possible, findings of the research with experienced engineers. Testing of new-hires will be carefully integrated with the research on five to seven year experienced engineers so that the results of research can be put into practice very soon after they become available. The testing of engineering seniors for selection purposes, which was originally proposed several years ago, will not be done. If mutually satisfactory arrangements with the deans of certain engineering schools can later be worked out, the experimental testing of some engineering senior classes may take place.

EJC and the Engineering Profession*

By T. A. MARSHALL, JR.

Administrative Assistant ASME, Formerly Secretary of EJC

The unity of the engineering profession is a topic of great interest to engineers. In the belief that the Engineers Joint Council can become the unity organization that the profession is seeking, the author shows how the Council is organized, and discusses what it is doing now and how it is developing.

Unity has several meanings. It is subject to different interpretations by different individuals. Unity can mean, for example, "absence of diversity." It can mean "uniformity"; or "a unity of sentiment"; or "unification." It can mean "continuity without deviation of change." These are some of the accepted definitions of unity.

Such unity is not the kind that the engineering profession wants, or needs, or means, or can achieve when engineers speak of unity. In dealing with this problem, as in dealing with any other problem, there must be fundamental agreement regarding its basic elements.

There would seem to be two essential elements of engineering unity. First, the unity organization must be formed, not to achieve unity in the afore-mentioned senses, but to achieve unity in the sense of solidarity. Solidarity connotes a community of interests, objectives, standards, and responsibilities that will permit the profession, as a group, to express its opinions, manifest its strength, or exert its influence as a unit in specific areas. This does not require "uniformity" or "absence of diversity" or "unification," or "continuity without deviation or change."

An excellent example may be found in the American Medical Association (AMA). This organization frequently is alluded to in discussions on engineering unity. Many doctors disagree with some of the policies and actions of AMA. Some doctors are not even members of AMA. However, the association does express the opinion of the medical profession as a group without the unanimity expressed in some of the definitions of unity previously mentioned.

Second, there must be—and this may be considered by some as heresy—a recognition, expressed in the purposes and actions of the unity or solidarity organization, of the value of self-interest, individual and organizational, as a motivating force toward successful and continuing operation. A unity organization cannot be formed or maintained without the support of engineers; their continued support cannot be obtained unless the unity organization includes, among its primary aims, aiding the engineer to improve himself and improving the professional climate for engineering.

Within the engineering profession there already are a number and a variety of organizations; unity organizations, at least in one sense. Engineers concerned with one broad area of engineering, such as civil, mechanical, electrical, etc., have formed societies to work together in de-

* This is a condensation of an article on EJC, its purpose and objectives, reprinted from *Electrical Engineering*, May, 1954.

veloping and promoting an interchange of ideas within those basic areas. Such societies have served, for years, as a core for their members within the technical areas of their competence. They have developed standards and codes for operation and safety that have become recognized and used by many outside of the profession. They have become national authorities and spokesmen within the technical areas of their competence. It must be remembered, however, that their primary reason for existence is to help their individual members develop themselves. This is a prerequisite to all other activities. Similarly, there are local or regional societies or councils that serve the common interests of engineers residing in a community or region.

Some effort must be directed toward self-development of engineers in order to create an organization that will enable engineers as a group to serve mankind without selfishness. When this is done, it will permit the individual members of the profession, and the profession as a whole, to make their greatest possible contribution to the national welfare. This, in turn, will create a climate in which the individual engineer can function more effectively as a recognized professional person.

The AMA and the American Bar Association are virile unity organizations within their professions primarily because they aid doctors and lawyers to develop themselves professionally. True, their contributions to the national welfare are notable, but those organizations are supported because they aid doctors and lawyers to develop themselves.

Areas of Unity

Next, consider the areas in which an effective unity organization in the enginering profession might operate to achieve these goals. There are problems arising from time to time within the profession that are generally national in scope and in importance that the existing societies individually are not equipped, nor in a position, to handle. Many of these problems are nontechnical but require a coordinated degree of technical competence in several fields.

These problems fall into two broad categories. First, those that affect the individual engineer only indirectly, and in much the same manner as they affect any individual citizen. These might be called national welfare or public service problems. Second, those that affect the individual engineer much more directly. These might be called professional problems.

Public Service Activities. In the first category are problems on which a small group of highly competent members of the engineering profession perform a much-needed service to the nation on behalf of the profession. These problems and their solutions are most important. They are being handled now, and have been handled for many, many years. The history of accomplishments in this area is impressive. It can be found in the annals of the Engineering Council of the National Technical Societies in America, founded in 1917, and its heir, The American Engineering Council, formed in 1920. At the current time, this is one of the major areas of the activities of Engineers Joint Council (EJC).

The importance of such activities has been recognized by many prominent engineers. The Honorable Herbert Hoover, first president of The American Engineering Council of the Federated American Engineering Societies, commented succinctly on this in his address to the first meeting of the American Engineering Council on November 19, 1920. (1). Mr. Hoover discusses the "foundation of individualism" upon which American civilization has been built. He goes on to discuss the growth and consolidation of voluntary associations within the economic system and the striving of such associations—employers, farmers, merchants, labor—"by political agitation, propaganda, and other measures to advance group interest."

Mr. Hoover goes on to state: "The Federated American Engineering Societies stands somewhat apart among these great economic groups in that it has no special economic interest for its members. Its only interest in the creation of a great national association is public service, to give voice to the thought of engineers in these questions."

Some examples of these national welfare activities, or service activities, are The American Engineering Council's study on "Waste in Industry" or its survey of commercial aviation in 1925. The latter study resulted in the establishment in the U. S. Department of Commerce of the Bureau of Aviation, the forerunner of the present Civil Aeronautics Authority and Civil Aeronautics Administration.

Current examples are the contributions of EJC to the development of a sound national water policy as reflected in their report, "Principles of a Sound National Water Policy"; or the contributions of EJC through its National Engineers Committee on the Industrial Disarmament of Japan, or in the statement of EJC's Atomic Energy Panel to the Joint Congressional Committee on Atomic Energy, recommending changes in the Atomic Energy Act to permit the engineering profession to make its maximum contribution in the development of atomic energy for peaceful purposes.

Professional Activities. Most members of the profession see and understand the necessity for these national welfare or public service activities. Many of them, however, find these insufficient as a rallying point for their own enthusiasm. They will not underwrite a unity organization devoted solely or primarily to such activities. Unless such an organization pursues activities that will help individual engineers to develop themselves professionally, they, in turn, will not give their support or provide the grass roots backing through the technical societies so necessary for the continuity of any successful unity organization to serve both engineers and the nation. Therefore, for this reason, if for no other, there must be concern for problems in the professional area, the solutions to which can be felt by the individual engineer.

In this area, for example, may be considered the problems of the development of the engineer in his profession. This is done through such activities as the accrediting of engineering curricula, the development of standards of ethics, the development of adequate minimum registration requirements, progress toward uniformity of registration, and the like.

Also in this area are studies that have to do with the relations of the engineer with his employer, and the related studies of engineering income, supply, and demand, as well as the problems of monitoring national or area-wide legislation from the standpoint of improving or preventing damage to the climate for the practice of the profession of engineering.

. . . . .

The now-classic report of EJC, "The Engineering Profession in Transition," published in 1946, is another example of a professional area activity. The activities of the EJC Engineering Manpower Commission and the National Society of Professional Engineers (NSPE) in their efforts to improve the utilization of engineers, and their continuing efforts to provide comprehensive and basic information of value to employers of engineers and to engineers themselves in the resolution of their mutual problems relating to working conditions, also might be considered. Another example can be found in the activities of the EJC Labor Legislation Panel. This panel was most successful in having the current professional provisions written into the Labor Management Relations Act of 1947, the Taft-Hartley Act. They have continued their efforts to have these provisions retained in any consideration involving amendment of the Act.

Still a further example can be found in the joint efforts of EJC and NSPE in successfully having the engineer employee practicing his profession exempted

from the provisions of the Salary Stabilization Act.

Public Relations. Related to both of these, professional activities and national welfare activities, is the necessity for an over-all public relations program. A successful public relations program will be a partial solution, at least, of the problem of recognition of the engineer by those outside of the profession.

While the problem of recognition needs a considerable amount of effort behind it, there is progress being made in this area too. Through the efforts of EJC and its committees there has been a rapidly growing appreciation of the engineering profession in the Congress. The activities of the EJC Engineering Manpower Commission in its participation in planning for national mobilization have served to underscore the important contribution of engineers to the national economy, and the necessity for forthright action in connection with the mobilization of specialized personnel. They have been successful in arousing an awareness and understanding of this, not only in the Congress, but also within the Department of Defense, and in other executive branches of the government.

Previous Unity Efforts

What can be learned from the history of previous attempts to establish a unity organization? The most notable previous unity effort on the part of the engineering profession was The American Engineering Council (AEC) of the Federated American Engineering Societies. The AEC was established in 1920 for the betterment of the profession by opening up opportunities for engineering services in and out of the government. It functioned through a council and an executive committee. The Council was composed of representatives of member societies on the basis of one representative for each 1000 members. Membership in AEC ranged from a low of 19 societies, 7 national, 5 state, and 28 local societies in 1932, to a high of 54, 8 national, 18 state, and 7 local societies in 1940, the year in which it was dissolved.

The executive committee or administrative board, as it was called later, was composed of 30 members. Actually it was an unwieldy organization from the standpoint of executive action inasmuch as a two-thirds affirmative vote was required in all decisions affecting policy or action.

Financial support came from assessments of member organizations. Although its membership was national, regional, and local, financial support came primarily from three national engineering societies: The American Society of Mechanical Engineers (ASME), the American Institute of Electrical Engineers (AIEE), and after 1929, the American Society of Civil Engineers (ASCE). Annual contributions from these three organizations accounted at times for as much as 95 per cent of AEC income, and never amounted to less than 75 per cent.

The major objects of the AEC were: "to further the public welfare wherever technical and engineering knowledge and experience were involved" and "to consider and act upon matters of common concern to the engineering and allied technical profession." During the nearly 20 years of its existence, the AEC made many worth-while contributions to the national welfare through its research activities, and through its services to legislators.

A brief history of The American Engineering Council was prepared by A. F. Bochenek in 1951 after an exhaustive study of the old records of AEC. Mr. Bochenek, a member of the editorial staff of ASME at the time, says in his introduction, "Among those who were active in AEC affairs, there seems to be no unanimity of opinion why the AEC, after the signal achievements of the 1920's, failed to sustain the high level of interest in unity among member engineering societies that was so evident when it was

launched during the postwar days of World War I."

In addition to what appears to be one of the major reasons for the AEC's failure, organizational (and financial) defects, there is another possible answer, imbalance of program. To quote further from Mr. Bochenek, in a section covering AEC's services to the engineering profession he says, "While the AEC did serve individual engineers who asked for aid and information, most engineers regarded it as a remote organization working in an indirect and intangible way for the betterment of their profession."

When one considers the success enjoyed by ECPD in comparison, one notes immediately the concentration of its programs on problems and activities in the professional area. To repeat, ECPD is the recognized agency for the accrediting of engineering curricula. ECPD has developed a widely accepted "Canons of Ethics for Engineers" dealing with the relations of the individual engineer with the public, with other engineers, and with his client or employer. ECPD has spearheaded a program in cooperation with industry and the colleges, to aid the young graduate to develop himself technically and professionally during the 5 years immediately following his baccalaureate degree. ECPD, through its Guidance Committee, has done much to bring the story of the engineering profession to students in the secondary schools and to their parents and teachers. ECPD has developed and is spearheading the acceptance of uniform grades of membership in the technological societies. These activities are appreciated, if not endorsed, by individual engineers.

In summary then, two things can be learned about unity from the failure of the AEC. First, an organization must be planned so that the views of the members of the profession will be considered thoroughly in developing policies within which the unity organization will act. The organization must provide for effective executive action in line with those policies, but without the necessity of continual referral back to the constituent members or affiliates.

In providing a channel of communications through which the views of the members of the profession will be considered, the organization must be so tempered that it will not be subject to violent fluctuations of opinion. This is somewhat similar to the problems faced by the founding fathers of the country in developing its method of government. They designed the policy-making segment of the government to reflect the will of the people through their representatives in the Congress. But this takes time. The Congress is not readily sensitive to rapid changes. It takes time for the will of the people to be reflected in Congressional action. The executive branch of the government has the power to act within the framework of laws (or policy) established by the Congress.

Impatience often is expressed at the apparently inordinate amount of time it takes in the development of laws by the Congress. Time, however, is a great means of tempering. Most people, at times, have been impatient in their own business relations. Most have been tempted to act immediately on some problem, and later have been thankful that they took no action on the spur of the moment.

The second thing to be learned from the failure of the AEC is even more important, the effect of imbalance of program. The efforts of AEC were concentrated primarily on national welfare activities.

Its services to members of the engineering profession were confined largely to two major activities. AEC maintained a roster of more than 115,000 names and records that served as a fountainhead of information about engineers conveniently accessable to government departments and commercial interests seeking the services of competent engineers. They were instrumental, in 1935, in encouraging the Bureau of Labor Statistics to conduct a

comprehensive survey that provided, for the first time, reliable information on engineering salaries on a profession-wide basis. As Mr. Bochenek stated, however, most engineers regarded AEC as a remote organization. Thus the grass roots support, and grass roots demand for its continuance, did not exist.

Engineers Joint Council

Why and How It Came Into Being. The EJC was organized formally in 1941 as the Engineers Joint Conference. The Conference grew out of a liaison relationship that had existed between the secretaries of the four Founder Societies for many years.

Actually, the Conference was an outgrowth of the Engineering Council of the National Technical Societies of America formed by the Founder Societies (ASCE, American Institute of Mining and Metallurgical Engineers, ASME, AIEE) in 1917. The 1917 Council was formed to work with the government or engineering problems involved in developing the automobile, the tank, and the airplane into major weapons of national defense. When the AEC was formed, the 1917 Engineering Council discontinued its operations and turned over to the AEC its records, its funds, and its Washington office and staff. The liaison relationship between the secretaries that was engendered by this World War I organization was continued.

Early in the mobilization immediately preceding America's entrance into World War II, the Founder Societies received a number of requests from various governmental activities for information and aid in areas of interest to the profession. It was decided that a more formal organization was needed and the Engineers Joint Conference was established in 1941 composed of the presidents and secretaries of the participating societies. The American Institute of Chemical Engineers became the fifth participating member in 1942.

As the scope of activities expanded, the functions of this organization became of greater significance than that implied by "Conference." The name was changed to Engineers Joint Council in September 1945. Representation of the constituent societies on the Council was increased and a formal constitution adopted.

Expansion of EJC. In 1949, EJC, through its Committee on Increased Unity, sponsored a meeting to discuss the development of increased unity within the engineering profession. Out of this meeting, an Exploratory Group containing representation from ten other national societies in addition to the five EJC societies was formed. During more than 2 years of study, the Exploratory Group developed a program and plan acceptable to most of its members that was submitted to EJC in January 1952.

After some discussion in EJC, its constitution was modified so that the first step in developing the unity organization in accordance with the recommendations of the Exploratory Group could be taken. The first modification of the EJC constitution changed the requirements for membership to permit the extension of invitations to additional societies to join EJC and, at the same time, provided proportional representation from its members.

The change in constitution was ratified by the five constituent societies of EJC by December 7, 1952, and on December 31, 1952, invitations were extended to eight additional societies to join EJC. Acceptances were received from three: American Water Association, The Society of Naval Architects and Marine Engineers, and American Society for Engineering Education, bringing the membership of EJC to eight constituent national societies.

Three of the eight societies invited to join EJC, American Association of Engineers, American Society of Heating and Ventilating Engineers, and the Institute of Aeronautical Sciences, took no action

on the invitations extended and they expired on December 31, 1953.

Two of the eight societies rejected the invitation to join EJC. In its letter of rejection, the Institute of Radio Engineers (IRE) requested continued cooperative activity with EJC on specific problems of mutual interest. Their rejection was dictated by two basic policies of long standing. First, that IRE shall not engage directly or indirectly in legislative activity. Second, that IRE as a society is not entitled to represent its members as individual members of the engineering profession, or, as a body, on social or general professional matters, and shall not, as a society, take a stand even on technical matters.

After considerable study, and additional meetings between a special joint committee consisting of three members of EJC and three representatives of NSPE, the latter organization declined to accept the invitation to join EJC. In the resolution adopted by the board of directors of NSPE on November 7, 1953, the invitation was declined "at this time, in accordance with the firm conviction of this Board that no organization can adequately represent the engineers of this nation, unless that organization is based primarily on individual membership and constituted to assure prompt and effective means of communication between the individuals, their local or state units, and their national governing body." The resolution goes on to express the firm desire of NSPE to continue mutual efforts toward the most effective action possible between the two organizations.

While NSPE did not accept at this time, the study resulting from the joint committee did much to further a mutual understanding between the two organizations. In addition, it has provided a very valuable document for the guidance of EJC. The Joint Committee on Relations Between EJC and NSPE is being continued by both organizations further to explore areas of mutual cooperation between the two societies.

Organization and Objects of EJC. The present Council itself its composed of 19 representatives of the eight constituent societies in proportion to their membership. Representatives and alternates on the Council must be members of the governing boards of the societies they represent. The presidents of the constituent societies are members ex-officio of the Council. The president and vice-president of EJC and the members of the Executive Committee are elected from among the representatives at the Annual Organizational Meeting to serve for one year. The EJC constitution provides that the president, the vice-president, and the other members of the Executive Committee each must be from a different society.

The objects of EJC as expressed in its constitution are as follows:

1. To advance the general welfare of mankind through the available resources and the creative ability of the engineering profession.

2. To promote cooperation among the various branches of the engineering profession.

3. To advance the science and the profession of engineering.

4. To develop sound public policies respecting national and international affairs wherein the engineering profession can be helpful through the services of the members of the engineering profession.

There is ample recognition here of the necessity to provide a balanced program. EJC actually carries on activities in both the national welfare or public service area and also in the professional area.

Public Service Activities. EJC's activities and the work of its committees fall into both of the broad areas previously mentioned, national welfare or public service activities, and professional activities.

In the first category, its Committee on Engineering Sciences cooperates with the National Science Foundation in initiating

and developing basic research in the engineering sciences. That committee also assists members representing engineering on the National Science Foundation Board. It has a task committee working actively with the National Science Foundation on the development of the engineering section of the National Scientific Register.

The EJC Committee on International Relations acts as a coordinating agency between the profession in the United States and abroad. The committee has been working actively with the Pan American Federation of Engineering Societies (more familiarly known as UPADI from the Spanish title, Union Panamericana de Asociaciones de Ingenieros). EJC is the United States member of UPADI. The Committee on International Relations was instrumental in helping to rebuild the engineering libraries of war-torn countries by acting as a clearinghouse for contributions of books that were delivered through the medium of the United States Book Exchange.

EJC also has an Advisory Committee to the Lewis Historical Publications, the official publishers of "Who's Who in Engineering." There is representation, not only from the eight constituent societies of EJC, but also from the Institute of Aeronautical Sciences, Engineering Institute of Canada, the IRE, Society of Automotive Engineers, and NSPE.

In addition to its work on the industrial disarmament of Japan, EJC's National Engineers Committee has continued to function in an advisory capacity to government agencies such as the Federal Civil Defense Administration, and the President in connection with the establishment of the St. Lawrence River Joint Board of Engineers.

Professional Area Activities of EJC. In the area of professional development, EJC is continuing, through its Special Surveys Committee, its surveys of supply, demand, and professional income. NSPE is represented on that committee also. A study of "Professional Income of Engineers in 1953," covering the income of nearly 70,000 engineers employed in industry, education, and government, recently was released.

The Engineering Manpower Commission of EJC has been working actively for the past 3 years to secure the most effective use of engineers in the national health, safety, and interest. In this area, it has done much to stimulate the interest of qualified high-school graduates in careers in engineering. It also has done much to promote more effective utilization of engineers, not only by the government, but also by industry.

Of major significance in the professional area, however, is the work of two committees. First, the Committee on Employment Conditions, through the constituent societies, has been making a study of employment conditions for engineers. While its work is not yet complete, that committee is studying the interest of engineers in collective bargaining, in professionalism, and in other activities which affect their employment conditions.

Second is the Committee on Recognition of Specialties in Engineering. As a result of a suggestion that came to EJC through the Joint Committee on the Advancement of Sanitary Engineering, a committee was formed to consider the problem of recognition of specialties in engineering. This need was emphasized by the difficulties encountered by sanitary engineers in being recognized as competent within their specialty, especially by those outside of the engineering profession. Sanitary engineers work very closely with members of the Public Health Service, and with the medical profession.

After the EJC Committee on Recognition of Specialties was established, the problem was discussed with the Joint Committee on the Advancement of Sanitary Engineering, and the EJC committee is watching with a great deal of interest the work being done by the joint committee in developing plans and pro-

cedures for recognition of sanitary engineering as a specialty.

Current thinking is along the lines of specialty boards to examine candidates in a somewhat similar manner to that employed in the medical profession. When the plans and procedures have been worked out in full detail and have been tested in the pilot study on sanitary engineering, they unquestionably will be extended to other fields cutting across the interests of more than one of the constituent societies. Hydraulics and nuclear engineering are two examples.

Other EJC Activities. EJC is in the process of changing. It is entirely different now than it was 2 years ago. As its activities progress, and as the Council studies and implements the recommendations of the Exploratory Group, it will continue to change. It can become the unity or solidarity organization for the profession.

In this connection, there are two most important activities. One of the recommendations of the Exploratory Group concerned the affiliation of state, regional, and local societies with EJC. A special committee now is working actively on that problem. That same committee also is studying the affiliation of national societies that meet all the requirements for EJC membership except that of size.

The second activity of interest is the matter of individual participation in EJC. This is deemed to be of such importance that the Executive Committee itself is devoting additional time to the problem.

It is hoped that the individual members will follow news of EJC and submit their suggestions for improvements, especially improvements that will help build EJC into the organization which engineers want and need.

Conclusions

If, in its activities, EJC gains the support of the individual members of the engineering profession, it can become the unity organization that engineers have been looking for. In order to be successful, however, it must have the interest and support of the individual engineer.

However, those who desire a collective bargaining agency as a unity organization will have to look elsewhere. EJC cannot and will not become a collective bargaining agency, nor will the existing technological societies.

To those who point to the strength of unity organizations in the medical and legal professions, remember that both of those professions are predominantly self-employed. There is no collective bargaining problem there. To attain public recognition and true professional status, especially in the eyes of the public, initiative, resourcefulness, creativity, and individual incentive must be encouraged among the members of the professions. These will be the tools through which engineers can be developed professionally, the practice of engineering improved, and the profession can provide effective services to the national welfare, or in the public interest. These factors are the direct opposite of collective bargaining.

Engineers as professional people have an obligation to devote a share of their time, efforts, and funds as a service to the nation in matters affecting the national welfare or in the public interest. If they do not carry on such activities, they will not maintain a professional status.

Activities of the type carried on by EJC are mandatory. It is of tremendous significance that only a year after AEC ceased its operations, engineers were forced to form another organization, EJC, to fill this need or concede that the engineering profession as a whole was voiceless in matters of national concern. Since 1917, there has been, except for 1 year, an organization engaged in such activities.

A successful and continuing unity or solidarity organization to serve the engineering profession can be built upon the framework already established in EJC

and the developments it is undergoing, if engineers will lend it their constructive support. Unless EJC is built into the spokesman for the profession in these areas of activity, engineers will find themselves represented by other, less-qualified, organizations hardly distinguishable from labor unions. What engineers, as individuals, get from EJC, or from any other organization for that matter, will be in direct proportion to what engineers as individuals put into it.

REFERENCE

(1) "Some Phases of Relationship of Engineering Societies to Public Service," Herbert Hoover. *Mechanical Engineering*, New York, N. Y., vol. 42, December 1920, p. 722.

Lamme Award

The Committee on Lamme Award is always anxious to get nominations for the Award from the membership of the Society. Any member may place a name in nomination; the selection will be made by the Committee by letter ballot.

The Lamme Award consists of a gold medal and bronze replica bestowed annually upon a distinguished engineering educator for excellence in teaching and contributions to the art of teaching; contributions to research and technical literature; achievements which contribute to the advancement of the profession; and engineering administration. The Lamme Trust Fund was established in memory of Benjamin Garver Lamme. For a brochure describing the Award and a nomination form, please write to the Secretary, Professor A. B. Bronwell, Northwestern University, Evanston, Illinois.

Nominations should be sent to the Chairman of the Committee, Dean F. E. Terman, College of Engineering, Stanford University, Stanford, California by February 1, 1955.

The George Westinghouse Award

The George Westinghouse Award is an annual award established in 1946 by the Westinghouse Educational Foundation to recognize and encourage outstanding achievement in the teaching of students of engineering. The Award consists of $1,000, together with an engraved certificate.

The Award has been established to encourage younger men who have shown, by their past record, evidence of continuing activity as superior teachers. To them the Award may serve not only as a reward but as an incentive toward further achievement.

In order to achieve this intent, it is deemed essential to limit the Award to those who have not reached the age of 45 by the date of the annual presentation.

Nominations may be made by any person, organization, or group and are to be submitted before February 1, 1955 to the Chairman of the Committee on Award, Professor F. H. Pumphrey, University of Florida, Gainesville, Florida. Nominations must be made on forms available from either the Chairman of the Committee or from the Secretary of the Society. Nominations should be accompanied by significant evidence supporting statement and claims.

A Suggested Research Policy for the Guidance of Engineering Schools

Adopted by ECRC, June 1954

By ERIC A. WALKER

Dean of Engineering, Pennsylvania State University

The following statement of Research Policy was adopted by the ECRC at the Annual Meeting of the ASEE, June 1954.

Introduction

The primary functions of a university are generally recognized as (1) instruction, (2) advancement of knowledge and (3) public service. In an engineering school these three functions may be integrated to the advantage of students and faculty, the advancement of the art and science of engineering, and the welfare of the nation. In many academic institutions, the trend in research policies is towards research primarily motivated by scientific curiosity. Engineering, however, is by its very nature the application of art and science; hence it is essential in engineering to include applied research and development.

Role of the Professional Engineer

The professional engineer is a practitioner who depends upon Art and Science in the utilization of materials and natural forces in the creation of desired structures, products, processes or devices. Knowledge of the physical sciences and of the engineering sciences forms important background for predictions of the performance of components and systems, but engineering design is also an art requiring sound judgment, practical experience, creativeness, and intuition. The engineer needs an absorbing interest in the problems which must be solved and a sense of responsibility for solving them satisfactorily. He usually must reach his conclusions regarding an adequate design within a limited time and without full information, frequently unable to wait for all the refinements of data necessary for a completely scientific solution. Cost factors must also be considered, and the sound engineering solution is often a compromise between what is technically desirable and what is economically feasible.

Engineering Instruction

In meeting the obligation to prepare students to practice engineering, engineering schools have properly given their first attention to the scientific basis for engineering practice, the conventional four-year program being composed predominantly of courses in the physical and engineering sciences. This emphasis is appropriate because these subjects form a backbone of knowledge necessary for engineers and because they are well suited to formal instruction, but this emphasis should not obscure the fact that engineering schools exist to educate engineers, not scientists. Integration and application of this scientific knowledge to problems characteristic of the various branches of engineering occupies an essential part of the curriculum; in fact, without courses which introduce the student to the practice of engineering and some actual practice itself which is gained from independent work, particularly in the preparation of theses for advanced degrees, there would be little reason to organize separate engineering schools.

Competence in professional engineering requires practice. Engineering faculties must therefore in some way practice engineering, if they are to inspire and guide

students toward professional practice, by posing novel and challenging problems of increasing difficulty and current significance.

Advancement of Knowledge

The engineering school's responsibility for the function of the advancement of knowledge cannot be fulfilled by concentrating solely on research devoted to the discovery of scientific facts and data which will be useful to engineers, important though that research is. The advancement of knowledge in the field of engineering also encompasses improvements in the art and practice of engineering itself. The development of new processes, the evolution of new methods of design and construction, the formulation of techniques for a better balancing of complex factors such as cost, reliability, performance, and ease of maintenance will constitute significant advances in knowledge for engineers.

Public Service

Engineering is a profession. As in the case for all of the professions, engineers have an obligation to public service. It is appropriate, therefore, that engineering schools undertake programs of research or development on the basis of public service which may not contribute as significantly to instruction or the advancement of knowledge as other programs of research.

Policy Summary

Under these circumstances, it is to be expected that the research program of an engineering school should properly embrace the following types of activities:

a. Research to discover basic or fundamental scientific principles and facts which will advance the science of engineering.
b. Applied research or development of specific devices or processes which will develop the competence of teacher and student, thereby serving the engineer in a manner parallel to the clinical studies of the physician.
c. Activities which serve the public interest, as for national defense, public health, or general industrial and agricultural progress.

ECPD Annual Meeting

October 28–29, 1954 Hotel Alms, Cincinnati, Ohio

The subject of the meeting will be "The First Five Years of Professional Development." This pertains to the education and training of young engineers in industry. The Annual Dinner on October 29 will have as dinner speaker James H. Taylor, Assistant Director for Manpower, Office of Defense Mobilization. The title of his address will be "The National Manpower Outlook from the Point of View of the Profession." The dinner and conferences are open to all engineers who are interested in attending.

For information and reservations write to Professor Cornelius Wandmacher, Civil Engineering Department, University of Cincinnati, Cincinnati, Ohio.

American Society for Engineering Education

Report of the Vice President in Charge of Instructional Committees and Divisions For the Year 1953–54

During the past year Committees and Divisions of the Society have been unusually active in many aspects of engineering education, stimulated in large measure by the thought provoking issues growing out of the work of the Committee on Evaluation. The vigorous and penetrating discussion that resulted from the Preliminary Report of this Committee among institutional groups on campuses throughout the country has had a notable effect upon the activities of specific Committees and Divisions of the Society, encouraging them to cooperate in an overall effort to strengthen and improve the processes of engineering education.

The Humanistic-Social and English Divisions of the Society during the year completed arrangements for a research project into the cultural stem of engineering curricula, and the Society has obtained a grant of $30,000 from the Carnegie Corporation to finance the study. Dr. Edwin S. Burdell, President of Cooper Union, has generously agreed to serve as Chairman of the Society's Committee on the Humanistic-Social Research Project, and Dr. George Gullette has been given leave of absence from North Carolina State College in order to serve as the Project Director. Organization for carrying on the study and some visits to engineering schools in which the humanistic-social program has been developed effectively were arranged during the spring of 1954. It is planned that the field work will be completed in the fall and winter of 1954 with the expectation that a preliminary report can be submitted at the Penn State Annual Meeting of A.S.E.E. in June, 1955. The study will be concerned not only with the discovery and discussion of distinctive programs in the humanities and social sciences currently in operation among undergraduate engineering curricula, but also with recommendations as to promising ways in which the humanistic-social stem can be made to contribute most effectively to the education of prospective professional engineers.

The Society's Committee on Graduate Study is making plans to conduct a comprehensive study of graduate engineering education and during the current year has been working with the Executive Board in an effort to obtain appropriate financing for the project. The need for this study of graduate curricula has been pointed out in the Interim Report of the Committee on Evaluation of Engineering Education. There is reason to hope for adequate support of this important undertaking and to expect that it can be initiated in 1954–55.

In the summer of 1954 the Society will operate the largest number of summer schools that it has ever conducted in any one year. These are as follows:

1) An Evaluation of Analytical Techniques of Engineering Economy June 12 and 13, 1954, at the University of Illinois, sponsored by the Committee on Engineering Economy
2) The Elements of Design of Digital Control Circuits

June 18–20, 1954, at the University of Illinois, sponsored by the Division of Electrical Engineering

3) The Development of Creative Thinking in Engineering
August 30 to September 4, 1954, at the General Electric Company, Schenectady, New York, sponsored jointly by the General Electric Company and the Division of Educational Methods

4) Workshop for the Humanistic-Social Study Project
June 18–20, 1954, at the University of Illinois, sponsored by the Humanistic-Social Division

5) The Evaluation of the Engineering Significance of Graduate Training in Mechanics
June 11 and 12, 1954, at the University of Illinois, sponsored by the Division of Engineering Mechanics

6) The Teaching of Machine Design and Manufacturing Processes
June 18–25, 1954, at the University of Illinois, sponsored by the Division of Mechanical Engineering

In addition to these summer schools the Society also sponsored jointly with the Instrument Society of America a Symposium on Instrumentation Education at the University of Illinois on June 12, 1954.

Due largely to the vision and creative effort of Professor Bronwell, the Society has also given leadership to two important Summer Institutes in 1954. One of these, in the field of Solid State Physics in Engineering Education, is comprised of a preliminary conference of leading physicists and engineers at the University of Illinois in the spring of 1954, followed by an open conference at Carnegie Institute of Technology, June 21–25, 1954. The latter is open to engineering physics teachers.

The second Summer Institute, concerned with Nuclear Science in Engineering Education, began with a closed conference at Columbia University and is to be followed by an open conference available to A.S.E.E. members at Northwestern University, September 7–11, 1954. The purpose of these two programs is to consider the treatment of these important aspects of science in engineering curricula.

Noting the increasing interest in summer school activities, the Executive Board of the Society at its Rolla, Missouri, meeting in April, 1954, voted to establish in next year's budget an item of from $1000 to $2000 for the purpose of stimulating significant projects of this kind by making possible the underwriting of unanticipated deficits arising from such undertakings. The Board is of the opinion that summer schools should be planned as self-supporting enterprises but believes that a reserve fund is needed in order to provide for contingencies that cannot be foreseen. Without such a reserve for Committee and Division activities some eminently worth while projects may never be initiated because the sponsors are hesitant to take the financial risk involved.

Particular mention should be made of the splendid service rendered in 1953–54 by the Committee on Young Engineering Teachers under the leadership of Professor Howe of the University of Cincinnati. Not only has this Committee made its influence felt constructively on campuses throughout the country and in the Sections of the Society, but also the group conducted an eminently successful membership drive which brought in many new young engineering teachers to A.S.E.E.

Hearty thanks and appreciation are due to the officers of Committees and Divisions of the Society who cooperated so helpfully in arranging programs for the Annual Meeting. Almost without exception work began in the formulation of committee and division programs in the summer or fall of 1953, and the results of this early start are reflected in the excellence of the program finally arranged for the Annual Meeting at the University of Illinois. Many of the of-

ficers of Committees and Divisions took advantage of the fall meeting of A.S.E.E. and E.C.P.D. in New York to have preliminary round table conferences concerning committee work. Grateful acknowledgment should be made of the fine service so generously given by the editors of the periodic bulletins issued by various instructional sub-divisions of the Society during the year. These publications have been uniformly attractive in format and serviceable in content, bringing to special constituencies much valuable subject matter that otherwise would have been unavailable to them.

I wish to express my personal thanks also to members of the Committee on the Annual Meeting which worked with me in considering over-all plans. The schedule of activities for 1954 at the University of Illinois is generally similar to that of a year ago, but a substantial number of joint meetings have been arranged and every effort has been made to avoid conflicts. The opening session on Monday afternoon for reports of important activities of the Society, which was initiated at the University of Florida, has been continued this year since it appears to serve a useful function.

In conclusion, I want to express my sincere appreciation to all of the Chairmen of Committees and Divisions of the Society whose friendly cooperation has made my tenure of office both stimulating and enjoyable.

Respectfully submitted,
W. C. WHITE, *Vice President*

June 14, 1954

Annual Report of Vice President in Charge of Sections and Branches June 11, 1954

In this, my first year of work with Sections and Branches, I have become well acquainted with many of their worthwhile activities, and I have come to have a high respect for this very substantial base upon which the Society is built.

It has seemed to me that the Society as a whole suffers to some extent from a multifold expansion in many different, separate directions. We have the Engineering College Administrative Council and the Engineering College Research Council to deal with problems of our institutional members; we have divisions, one kind of which are associated with curriculum majors, such as Chemical, Civil, Electrical, Mechanical Engineering, and so on, and divisions of another kind which cut across major fields, such as English, Graduate Study, Educational Methods, Relations with Industry, and so forth. Then we have standing committees and ad hoc committees. All these kinds of subdivisions of our Society are in addition to Sections and Branches.

These kinds of subdivisions are desirable in themselves, but I think they, as well as the Society as a whole, can be strengthened by developing cross-ties, at least of certain kinds. Consider, for example, the Sections and Divisions. Divisions are organized around subjects, programs, and ideas; Sections are based on geography and membership. Divisions are active and productive of good program material, sometimes extending over years of development, yet they have no tangible, definite membership apart

from a small core of officers, directors, and perhaps an advisory committee. On the other hand, Sections have a definite membership—every one of our approximately 7,000 members belongs to some one section, yet programming is an ad hoc yearly task only indirectly related to the other activities of ASEE as a whole.

The section programs are excellent, as I know from first-hand observation. Even so, I think there would be a gain to the Society as a whole if we could achieve a tie between Sections (and Branches) on the one hand and Divisions (at least the kind that cut across fields and the similar kinds of committees) on the other. That is, a section might invite a division to help put on part of its annual program. The section chooses and works with the division according to its current interests. Such cooperation fosters section participation in the development of division ideas by presentation and discussion and strengthens both. The section is kept in a main current of Society activity; the division reaches more members and has more frequent opportunity to meet, although the section meeting may be restricted geographically. The section gets help with its programs. I believe this cooperation will lead to the better and more thorough development of educational ideas and their greater dissemination. I think the present over-all effectiveness of the Society can be criticized on the basis that there is a little talk about many basically good ideas, but the work on them is not carried very far toward the realization of full usefulness, and then the same ideas are brought up again and again without reference to previous discussion. A concerted drive in any period of a year or two might yield a firmer progress.

I have brought this suggestion to many of the sections, and there has been some indication from them of a willingness to try such cooperation next year. It is only fair to say, however, that the response has not been one of unanimous agreement. Of the divisions Relations with Industry has agreed to promote actively such cooperation and integration from its side.

Another kind of cooperation that has been and is being urged is with our associate industrial members, which now number more than 100. The same benefits that such members bring to national activities can be brought to sections if industry members are welcomed as participants in Section and Branch activities.

The Sections and Branches have had a healthy, vigorous year. In the fall the national officers planned their representation at all but the most distant section meetings and with only a few exceptions the plan was carried out. It appears that insofar as is possible it is desirable for the president of the Society to attend the Section meetings.

Respectfully submitted,

B. R. Teare, Jr.,

Vice President in Charge of Sections and Branches

The Annual Report of the Chairman of the Engineering College Research Council, June, 1954

The theme around which all of the work of the Engineering College Research Council has been centered during this past year is that of the creativeness of the engineer. To start off, a one-day conference was held in conjunction with the Engineers' Council for Professional Development in October, 1953. This conference consisted of three sessions; the first was one in which a noted artist, a well known composer, and an author and critic were asked to discuss creativeness in their own professions and, if possible, to analyze the creative process used in reproducing one of their own works. The second session was one in which a psychologist analyzed the creative process and attempted to point out some of the media by which creativeness could be stimulated. The third and last session was one which focused on creativeness in engineering as seen and analyzed by two well known industrial research scientists.

This meeting was an outstanding success, and it is regrettable in some ways that the publicity on it was not more widespread and that more people could not have heard the talks. However, it must be remembered that the meeting itself was of an experimental nature. Also, it is not customary for the Engineering College Research Council to hold a meeting in the fall.

There have been many demands for a printed brochure containing the talks. However, it must be realized that the talks, which were given on an informal conversational plane, are not readily adapted for printing. We have, for the past nine months, been trying to collect or prepare acceptable transcripts of the talks from the magnetic tape recording which was made on the occasion of the presentation of the addresses. In this we have received splendid, but sometimes reluctant, cooperation from the authors. At present we have all but one talk in hand, and as soon as that is available, a booklet will be printed containing not only the talks but also short biographical sketches of the authors. It is our belief that there will be many requests for this publication, since the session opened a new avenue of investigation for those who would try to stimulate creativeness in engineering.

Most of the work of the Council has been done through its committees. First should be mentioned a very hard-working group—the Committee on Relations with the Federal Government, which has functioned for another year under the able Chairmanship of Raymond Woodrow of Princeton University. This Committee, which meets often and which often offers counsel to federal agencies, has done a great deal to keep undesirable phrases and paragraphs out of the research contracts written between universities and the Federal Government. It has fought a vigorous fight to assure that the Government, in contracting for research, pays the proper share of its cost.

The Committee on Relations with Industrial Research Agencies is now entering a new phase. Whereas in the past the policy of the Committee was only to attempt to maintain the existing good relationships between industry and the Engineering College Research Council,

the present Committee is exploring the possibilities of seeking financial aid on a broad scale for research in the universities. There are, up to the present, no outstanding results of this effort, and this is to be expected since all negotiations are in the educational and exploratory stage only. However, it is believed that efforts in this direction will be continued by the Committee under the Chairmanship of Professor S. T. Carpenter of Swarthmore College. Dr. H. K. Work has served during the past year as the Chairman of the Program Committee, and as such he has lifted the heavy load from the shoulders of the Chairman of the Council. In so doing he has had an opportunity to become thoroughly familiar with all aspects of the Council's work, and therefore, it is very fitting and indeed the Council is extremely fortunate in having Dr. Work take over the Chairmanship for the next biennium.

For the past two years Professor Virgil Neilly of The Pennsylvania State University has served as Secretary of the Council. Anyone who is acquainted with the workings of the central offices of this or of any other group must realize that the Secretaryship of the Engineering College Research Council is not a position to be taken lightly. It has proven to be an extremely heavy load and one which requires a great deal of training, followed by a considerable amount of exploratory work and negotiation. It is my firm belief that the position as Secretary is not one in which the incumbent should be changed often, and certainly the change should not be made simultaneously with the changing of Chairmen. On the other hand, there's a great deal to be gained by having the Chairman and the Secretary on the same campus so that they can discuss things often and informally. It is, therefore, with a great deal of regret that I must announce that our present Secretary, Virgil E. Neilly, feels that the demands of this office are too heavy and that he must relinquish the Secretaryship as soon as the new officers can properly provide for the vacancy.

The Chairman himself has found this past two years very stimulating and rewarding. In addition to assuming the general guidance of the Council, the position has provided an opportunity to express the Council's wishes in many directions. The Chairman of the Council is, almost as a matter of course, a member of the Engineering Division of the National Research Council, which enables him to keep in touch with research administrators throughout the country. The Chairman of the Council also has opportunities to speak for the Council in matters concerning the Department of Defense, the Atomic Energy Commission, and the Congress of the United States.

In pursuing these matters, the present Council Chairman has taken a vigorous stand before the Joint Committee on Atomic Energy of the Senate and the House, pointing out that the colleges of engineering of the United States must be allowed to get into atomic research if they are to support and conduct a vigorous and up-to-date educational program, preparing people for careers in the general field of atomic energy. The Chairman has also voiced his opinion that the patent system, which has been long established and has proved its worth, must also be allowed to cover atomic energy matters, as well as other discoveries and inventions. Discussions have been held with members of the staff of the Atomic Energy Commission, and members of the Commission itself, and the Chairman of the Commission, pointing out that special arrangements must be made for universities to use atomic materials, to have atomic laboratories, and indeed to have atomic reactors on their campuses.

Direct representations have been made to the Assistant Secretary of Defense concerning the position of the colleges in the Department of Defense's research program. It has been pointed out that the colleges are in a position to do good

research and to do it at a cost which is fair to both the Government and the college, and at the same time to reap educational benefits which depend on the college's virile research programs. Protests were made both by letter and personally against trade associations and combinations of manufacturers who would oust the colleges from the Department of Defense's research program, and I am pleased to report that this matter appears, at least for the time being, to be resolved in our favor.

In closing, I would like to thank all the members of the Council and all the others who have been so willing to work for the good of the engineering colleges when called upon by the officers or the Chairman. Lastly, I would like to thank all those who have been so helpful during the past two years and who have made my period of office a very pleasant one.

ERIC A. WALKER,
Chairman, Engineering College Research Council

ASEE Reprints Available

The following reprints can be obtained from the ASEE, Northwestern University, Evanston, Illinois. Except where otherwise indicated, the price is 20¢ each or 12¢ each in lots of 100 or more. Please enclose check made out to ASEE.

Interim Report of the Committee on Evaluation of Engineering Education

Report of Committee on Engineering Education After the War

Code of Ethics of Interviewing Procedures

Improvement of Engineering Teaching

Industry's Interest in More Education for Engineers—Grinter

Cooperative Education at the Graduate Level

Present Status and Trends of Engineering Education in the United States

Developing Cooperative Engineering Between Engineering Colleges and Secondary Schools

Manual of Graduate Study in Engineering (50¢)

Annual Report of the Engineering College Administrative Council

July 1, 1953–July 1, 1954

Executive Committee Meetings

Two Executive Committee Meetings were held during this year. On October 14, 1953, during the Fall ASEE–ECAC Meeting, the Executive Committee met to consider reports from standing committees, discuss matters of current importance, and plan a program for the 1954 annual meeting.

Activities for the Year 1953–54

A. *Committee Activity for Year*

The *International Relations Committee* has been studying one of the significant problems in this field, the provision of a period of industrial experience for foreign nationals who are pursuing graduate study here. Dean Dawson is chairman of a subcommittee to study this problem and plans to develop a program for the Annual Meeting.

ECAC has actively joined with EJC to assist in furthering the objectives of a Western Hemisphere engineering organization, the Union Panamericana de Asociaciones de Ingenieros (UPADI). Dean Steinberg is coordinating the ECAC efforts to aid EJC in its relations with UPADI.

Although no formal meetings of the *Foreign Operations Administration (FOA) Cooperation Committee* were held, a considerable amount of aid was rendered to the FOA by locating staff members for service abroad and in assisting U. S. universities to make contact with universities outside this country.

During the year FOA was aided by the committee in discussions of contracts between:

University of Chulalongkorn in India with the University of Texas

A university in Korea with the University of Minnesota

A university in Indonesia with the University of California

A university in Turkey with the University of Nebraska and/or New York University

A university in East Pakistan with Texas A. & M. College

A university in West Pakistan with Colorado A. & M. College

University of the Punyab area of Pakistan with Washington State College

University of Yugoslavia with the University of Kentucky

University of Israel with University of the State of New York

A university in British Guiana with the University of Maryland

A university in Lima, Peru, with North Carolina State College

In addition to these FOA activities, contacts were maintained with the U. S. Office of Education and with the Committee on International Exchange of Persons Conference Board of the Associated Research Councils.

The Committee on *Selection and Guidance* has had two projects for the year, research on an engineering graduate placement test and a list of books and pamphlets to be provided to deans of en-

gineering. Preparation of the lists is moving forward. This committee is cooperating with the Educational Testing Service in the Placement Test research.

In April, 1954, representatives of Bell Telephone System, Detroit Edison, B. F. Goodrich, International Business Machine Corporation, and Westinghouse met with the Educational Testing Service to lay plans for a cooperative research program aimed at development of placement tests for graduates in engineering. It is hoped that tests developed through this research may supplement the judgment and experience of the interviewers and result in improved manpower utilization.

The *Manpower Committee* has had few critical issues which needed definite action. A resolution endorsing the work of the Engineering Manpower Commission was circulated to the membership of ECAC as Appendix II of the February, 1954, Executive Committee Bulletin.

Mr. Bridgman has been chairman of a subcommittee of the Manpower Commission of EJC to study the ROTC Branch General vs the Branch Material Programs. This study will be reported at the Annual Meeting of ASEE in Urbana. In addition, this committee has cooperated actively with the Survey Committee of EJC in its study of the current demand for engineering graduates. The Manpower Committee has cognizance over military affairs which affect the utilization of engineering graduates while the Military Affairs Committee considers the effect of military affairs on the educational programs of engineering colleges.

The *Military Affairs Committee* has made two major studies during the year. Last fall a study was made of the action of the Air Force in changing the regulations governing the award of commissions to students completing the advanced AF–ROTC program. From the standpoint of engineering education, no cause was found for protest by ASEE.

Later, a study was undertaken of the Army's interest in the Branch General ROTC Program. After due consideration it was reported that, as then administered, the Branch General Program offered no threat to engineering education and should not be protested. In order to check the opinion of the committee, all deans having ROTC units were canvassed. Those answering the question were over 3 to 1 opposed to a protest from ASEE against the Army's desire to change from Branch Material to Branch General.

The *Committee on Secondary Schools* is continuing its study of High School-College articulation in the fields of mathematics, physics, and chemistry.

B. *News Bulletins*

ECAC Executive Committee Bulletins were circulated twice during the year to our membership and to the ASEE officers and council members.

C. *Programs*

The Engineering College Administrative Council has presented programs at two national meetings during the year.

On October 15 at New York City, ECAC and ECRC presented a day's program on the theme "Creativeness in Engineering." Dean Everitt presided at the afternoon session which presented the point of view of the industrialist.

W. L. Everitt, *Chairman*
W. T. Alexander, *Secretary*

Report of the Treasurer

Ernest C. Davies
Certified Public Accountant
Evanston, Illinois

July 27, 1954

Mr. G. W. Farnham
American Society for Engineering Education
Evanston, Illinois

Dear Mr. Farnham:

In accordance with your instructions we have examined the accounts and records of the American Society for Engineering Education for the year ending June 30, 1954 and submit herewith the following statements prepared therefrom:

Exhibit I—Comparative Balance Sheets
Exhibit II—Comparative Statements of Changes in Funds and Special Accounts
Exhibit III—Comparative Statements of Income and Expense
Exhibit IV—Comparative Statements of Receipts and Disbursements

In connection with the statements as of June 30, 1954 we examined and tested the accounting records, traced the receipts as recorded to deposit, checked the disbursements, counted the securities on hand, and secured direct confirmation for all funds or securities in the hands of outside parties. Accounts receivable and payable were accepted as recorded without confirmation. With this exception our examination was made in accordance with generally accepted auditing standards and included all procedures which we considered necessary in the circumstances.

Based upon the above considerations, in our opinion, these statements and accompanying footnotes fairly present the position of the Society at June 30, 1954 and the results of operations for the year then ended.

Sincerely,

ERNEST C. DAVIES
Certified Public Accountant

AMERICAN SOCIETY FOR ENGINEERING EDUCATION
COMPARATIVE BALANCE SHEETS
EXHIBIT I

	June 30, 1953	June 30, 1954
Assets		
Current Fund:		
Cash—Checking Accounts (Exhibit IV)	$27,826.54	$ 39,539.38
—Savings Accounts		15,000.00
Petty Cash	300.00	300.00
U. S. Government Bonds—Series G	30,700.00	31,700.00
Accounts Receivable		
Advertising	3,588.01	2,494.47
Dues	1,800.00	1,800.00
Westinghouse Educ. Foundation	474.01	444.81
Due from Lamme Fund	279.58	355.94
Prepaid Travel Expense	425.00	425.00
Prepaid Postage and Supplies		530.00
Inventory	1.00	1.00
Furniture and Fixtures	1.00	1.00
Total Current Fund **	$65,395.14	$ 92,591.60
Life Membership Fund *		
Cash	212.06	
U. S. Government Bonds—Series G	1,000.00	
Due from General Fund	25.00	
Total Life Membership Fund	$ 1,237.06	
B. J. Lamme Fund		
Cash	290.25	290.25
Income Cash in Hands of Trustee	237.25	240.02
Principal Cash in Hands of Trustee	3.86	5.51
Securities and Mortgages	10,137.87	10,136.22
Total Lamme Fund	$10,669.23	$ 10,672.00
Total Assets **	$77,301.43	$103,263.60

* Life membership transferred to current fund of Society by ruling of Executive Board.

** The increase in current fund and total assets is due largely to funds received from outside organizations which are reserved for special projects. These funds are not available for general Society operation.

Liabilities and Capital	June 30, 1953	June 30, 1954
Current Fund:		
Due to Life Membership	25.00	
Other Accruals	4,234.56	1,006.00
	$ 4,259.56	$ 1,006.00
Dues Collected in Advance	$ 864.21	$ 771.25
Excess of Contributions over Disbursements (Exhibit II)		
Teaching Aids	6,228.11	6,767.51
Evaluation of Engineering Education	187.30	5,012.45
Humanistic-Social Research		20,457.15
	$ 6,415.41	$ 32,237.11
Surplus		
Reserve for Special Projects	5,317.19	5,317.19
Reserve for ECRC	4,253.16	6,430.19
Unappropriated Surplus (Exhibit II)	44,285.61	46,829.86
	$53,855.96	$ 58,577.24
Total Current Fund	$65,395.14	$ 92,591.60
Life Membership Surplus *	$ 1,237.06	
B. J. Lamme Fund:		
Due to General Fund	279.58	355.94
Surplus	10,389.65	10,316.06
Total Lamme Fund (Exhibit II)	$10,669.23	$ 10,672.00
Total Liabilities and Capital	$77,301.43	$103,263.60

* Life membership transferred to current fund of Society by ruling of Executive Board.

STATEMENT OF CHANGES IN FUNDS AND SPECIAL ACCOUNTS
EXHIBIT II

Current Fund Surplus	12 Months Ended June 30, 1953	12 Months Ended June 30, 1954
Balance at Beginning of Period	$46,107.19	$44,285.61
Add: Excess of Income over Expense		3,483.16
Transfer to ECRC Reserve		(2,177.03)
Transfer of Life Membership to General Fund		1,238.12
	$46,107.19	$46.829.86
Less: Excess of Expense over Income (Exhibit III)	3,491.18	
Transfer from ECRC (Exhibit III)	(1,803.46)	
Transfer of Income Cash to Lamme Fund	133.86	
Balance at End of Period (Exhibit I)	$44,285.61	$46,829.86

	12 Months Ended June 30, 1953	12 Months Ended June 30, 1954
B. J. Lamme Fund		
Balance at Beginning of Period	$ 5,304.81	$10,389.65
Add: Transfer of Income Cash from General Fund	133.86	
Contributions Received	5,000.00	
Earnings of the Fund	230.56	227.77
	$10,669.23	$10,617.42
Less: Award and Expense	279.58	301.36
Balance at End of Period (Exhibit I)	$10,389.65	$10,316.06
Receivable—Westinghouse Foundation		
Balance at Beginning of Period	$ 323.69	474.01
Add: Expense	150.32	220.80
	474.01	694.81
Less: Reimbursement Received		250.00
Balance at End of Period (Exhibit I)	474.01	444.81
Teaching Aids		
Balance at Beginning of Period	$ 6,975.12	$ 6,228.11
Add: Receipts	50.00	1,125.00
	$ 7,025.12	$ 7,353.11
Less: Disbursements	797.01	585.60
Balance at End of Period (Exhibit I)	$ 6,228.11	$ 6,767.51
Evaluation of Engineering Education		
Balance at beginning of period		$ 187.30
Add: Receipts	6,000.00	13,000.00
	$ 6,000.00	$13,187.30
Less: Disbursements	5,812.70	8,174.85
Balance at end of period (Exhibit I)	$ 187.30	$ 5,012.45
Humanistic-Social Project		
Receipts		$30,000.00
Expenses		9,542.85
Balance at end of period (Exhibit I)		$20,457.15

COMPARATIVE INCOME AND EXPENSE STATEMENTS
EXHIBIT III

	12 Months Ended June 30, 1953	12 Months Ended June 30, 1954	Budget 1953–1954
Income:			
Current Dues—Individual	$40,394.45	$43,128.72	$40,600.00
—Institutional	9,185.00	12,877.60	10,000.00
Sale of Publications	2,887.00	3,271.71	2,800.00
Advertising	13,390.97	17,502.89	18,500.00
Interest on Bonds	792.50	792.50	780.00
ECRC	247.08	2,177.03	
Refund Unused Registration Fee Annual Meeting	689.24	527.27	
Miscellaneous	269.95	64.27	
Total Income	$67,856.19	$80,341.99	$72,680.00
Expense:			
Cost of Publications	26,062.46	29,832.45	30,000.00
Secretary's Salary	7,500.00	7,500.00	7,500.00
Assistant Secretary's Salary	3,240.00	3,240.00	3,240.00
Clerical Salaries	8,833.06	10,534.79	10,860.00
Retirement Emeritus	1,360.00	1,360.00	1,360.00
Travel—Secretary, Asst. Secretary, Office Secretary	1,906.51	2,649.91	2,450.00
Postage, Telephone and Telegraph	2,364.13	1,840.55	2,400.00
Supplies and Sundry Printing	4,342.65	5,415.65	4,500.00
Dues—American Council on Education	200.00	400.00	200.00
Dues—EJC	204.00	652.28	550.00
Contribution—ECPD	500.00	700.00	500.00
Contribution—Life Membership Fund	25.00		25.00
Officers' Travel	1,886.57	2,348.32	2,500.00
Meeting Expense	3,069.30	2,604.37	2,500.00
Expenses—ECAC	1,301.37	915.85	2,200.00
Expenses—ECRC	6,400.54	2,525.38	4,350.00
Committees and Conferences	926.16	1,699.02	1,300.00
Bonding, Auditors and Other Fees	359.84	340.68	
Refunds		198.47	
Special Projects and Miscellaneous			1,000.00
Young Engineering Teachers Award	300.00	300.00	
Graduate Manual	367.80		
Cooperative Eng. Educ. Report	95.48		
Contribution to ECPD for Eval. of Eng. Educ.	100.00	100.00	
Purchase of Adding Machine *		292.25	
Purchase of Addressing Machine *		387.01	
Purchase of Typewriter *		830.30	
Purchase of Desk and Chair *		170.63	
Miscellaneous	2.50	20.92	
	$71,347.37	$76,858.83	$77,435.00
Excess of Income over Expense (Expense over Income)	(3,491.18)	3,483.16	(4,755.00)
Transfer to (from) ECRC Reserve	(1,803.46)	2,177.03**	
Balance to Surplus (Exhibit II)	(1,687.72)	1,306.79	

* Equipment purchased has been charged as operating expense rather than being capitalized. This is in accordance with previous practice as established by the Executive Board.

** Sale of ECRC publications.

COMPARATIVE STATEMENT OF RECEIPTS AND DISBURSEMENTS
EXHIBIT IV

	12 Months Ended June 30, 1953	12 Months Ended June 30, 1954
Cash—Beginning of Period	$29,627.76	$ 27,826.54
Receipts		
Dues—Current	47,044.20	52,755.10
—Back Dues	2,027.00	2,387.01
—In Advance	864.21	771.25
Sale of Publications	2,887.00	3,271.71
Advertising	12,550.40	18,596.43
Interest on Bonds	792.50	792.50
ECRC		2,177.03
Westinghouse Educ. Foundation	247.08	250.00
Lamme Fund		225.00
Life Membership Fund		238.12
Teaching Aids	50.00	1,125.00
Evaluation of Engineering Education	6,000.00	13,000.00
Humanistic-Social Project		30,000.00
Unused Registration Fee—Annual Meeting	689.24	527.27
Miscellaneous	345.48	64.27
Total Receipts	$73,497.11	$126,180.69
Disbursements		
Cost of Publication	26,112.46	30,196.45
Administrative and Clerical Salaries (1)	19,573.06	21,274.79
Retirement Emeritus	1,360.00	1,360.00
Travel—Secretary's Office	1,955.79	2,469.91
Postage, Telephone and Telegraph	2,376.38	1,854.55
Supplies and Sundry Printing	4,236.45	6,051.85
Dues—American Council on Education	200.00	400.00
Dues—EJC	204.00	652.28
Contribution—ECPD	500.00	700.00
Contribution—Life Membership Fund		25.00
Officers' Travel	1,844.93	2,389.96
Meeting Expense	3,251.16	1,911.39
Expenses—ECAC	1,301.37	815.85
Expenses—ECRC	2,778.84	6,147.08
Committees and Conferences	926.16	1,699.02
Bonding, Auditors and Other Society Fees	334.84	514.68
Refunds		198.47
Special Projects and Miscellaneous (2)	1,553.28	2,101.11
Westinghouse Award	75.32	85.80
Expense—B. J. Lamme Fund	204.58	216.36
—Teaching Aids Fund	797.01	585.60
—Evaluation of Engineering Education	5,712.70	8,274.85
—Humanistic-Social Research		9,542.85
Transfer to Savings Accounts		15,000.00
	$75,298.33	$114,467.85
Cash—End of Period (Exhibit I)	$27,826.54	$ 39,539.38

	12 Months Ended June 30, 1953	12 Months Ended June 30, 1954
(1) Administrative and Clerical Salaries		
Secretary's Salary	7,500.00	7,500.00
Assistant Secretary's Salary	3,240.00	3,240.00
Clerical	8,833.06	10,534.79
Total	$19,573.06	$ 21,274.79
(2) Special Projects and Miscellaneous		
Young Engineering Teachers Award	300.00	300.00
Graduate Manual	367.80	
Coop. Engineering Education Report	95.48	
Special Travel of President	687.50	
Contribution to ECPD for Evaluation of Eng. Education	100.00	100.00
Purchase of Adding Machine		292.25
Purchase of Addressing Machine		387.01
Purchase of Typewriter		830.30
Purchase of Desk and Chair		170.63
Miscellaneous	2.50	20.92
Total	$ 1,553.28	$ 2,101.11

INCOME AND EXPENSE, 1953–54
BUDGET, 1954–55

	12 Months Ended June 30, 1954	Budget 1954–1955
Income:		
Current Dues—Individual	$43,128.72	$ 49,100.00
—Institutional	12,877.60	12,000.00
Sale of Publications	3,271.71	2,800.00
Advertising	17,502.89	20,000.00
Interest on Bonds	792.50	780.00
ECRC	2,177.03	
Refund Unused Registration Fee, Annual Meeting	527.27	
Miscellaneous	64.27	
Total Income	$80,341.99	$ 84,680.00
Expense:		
Annual Meeting	2,604.37	3,000.00
Journal and Proceedings	29,832.45	30,000.00
Committees and Conferences	1,699.02	2,000.00
Postage, Telephone and Telegraph	1,840.55	2,500.00
Supplies, Expense, Sundry Printing	5,415.65	4,500.00
Travel Expense—Secretary's Office	2,649.91	2,000.00
Officers Travel Expense	2,348.32	3,000.00
ECAC	915.85	2,200.00
ECRC	2,525.38	4,350.00
Administrative Salaries	21,274.79	23,500.00
Retirement Emeritus Assistant Secretary	1,360.00	1,360.00
Bonding Fees and Auditors	340.68	375.00
Dues (American Council on Education)	400.00	200.00
ECPD (Contribution)	700.00	500.00
Contingencies and Sp. Projects	2,101.11	2,000.00
EJC Dues	652.28	700.00
Refunds	198.47	
Total Expense	$76,858.83	$ 82,185.00
Excess of Income over Expense	$ 3,483.16	$ 2,485.00
Transfer to ECRC Reserve	$ 2,177.03	
Balance to Surplus	$ 1,306.13	

Minutes of the Executive Board

A meeting of the Executive Board of the American Society for Engineering Education was held at the Urbana-Lincoln Hotel on June 13, 1954. Those present included L. E. Grinter, *President*, W. L. Everitt, B. R. Teare, Jr., E. A. Walker, W. C. White, *Vice Presidents*, G. W. Farnham, *Treasurer*, A. B. Bronwell, *Secretary*, C. E. Watson, *Assistant Secretary*, Thorndike Saville, guest; M. Strohm, office secretary.

Report of the Secretary

1. The Secretary reported that the Amendment to By-law IV had been voted upon favorably by 76% of the voting membership. The total number of ballots cast was 2,283.

2. The Secretary also reported on the new method of handling dues notices. Members under 36 years of age as of July 1 would be entitled to a lower dues status, but would be required to give their date of birth.

Report of the Treasurer

The Treasurer presented the tentative annual audit, which indicated an estimated excess of income over expense of $1,307 (final audit). The ECRC handled its principal publication costs in last year's budget, and for this reason its expenses were abnormally low this year. On the income side, individual and Institutional dues exceeded budget by $4,300, in part due to the success of the Associate Institutional Membership drive. Most items of expense were in line with budget except for ECRC and ECAC expenses, which were held down to effectuate economies.

Reports of Vice Presidents

Written reports of the four Vice Presidents on activities within their jurisdictions were presented.

Amendments to EJC Constitution

Dean Thorndike Saville, President of EJC, reported on the proposed changes in the EJC Constitution. The amendments provide for three new classifications of membership as follows:

a. *Associate Membership*, consisting of national engineering societies which meet the requirements for membership in EJC except that they do not have the number of members required for full membership;
b. *Affiliate Members*, consisting of engineering societies which are regional rather than national in scope, but which have the qualifications for voting members equivalent to those required of constituent societies.
c. *Individual Members*, consisting of engineers who hold voting membership in any one of the constituent societies of EJC, or who hold an engineering degree from a college of recognized standing, or who have equivalent attainments, including at least six years of engineering experience of satisfactory character.

The discussion revolved around the desirability of instituting individual membership. The principal values of individual membership are: (1) to bring the members of the engineering profession into closer proximity to the operations of EJC, and (2) to provide additional income to finance EJC. The objections are:

> It is unlikely that EJC would get a very substantial number of individual members. If EJC has only a few thousand individual member, this would greatly weaken its position in making recommendations to Congress and the federal government on national problems bearing upon engineering, since it would be extremely difficult to sustain the idea that EJC represents the entire engineering profession if it has only a few thousand individual members. The problems handled by EJC are problems of national scope, requiring experienced judgment on the part of the best qualified engineers of the country. These are not problems which can be referred to an individual membership for "vote."

The Executive Board suggested that EJC could establish meaningful grass roots con-

nections with the individual members of the engineering profession by preparing publicity releases to be published monthly in each of the engineering societies' journals. These would describe the current progress on principal EJC activities. They would invite individual members of the engineering profession to offer suggestions and recommendations on EJC projects and thus establish a constructive grass roots contact with the entire engineering profession, rather than with a few thousand individual members.

The Executive Board recommended to the General Council that it approve all of the proposed Constitutional Amendments except Article 5, dealing with individual members, and to table this amendment until the Fall Meeting of the Executive Board and General Council.

Division and Committee Budgets

The Executive Board voted to allow an annual budget of $35 for each division and committee, without special request. If a division or committee wishes an amount in excess of $35, it should present a specific request to the Board.

UPADI and EUSEC Representatives

It was reported that the ASEE representative to UPADI will be Dean W. A. Lewis of Illinois Institute of Technology. This is a meeting of Pan American countries dealing with engineering and engineering education. The alternate delegate will be Dr. Ralph Morgen of National Science Foundation.

The ASEE representative to EUSEC (European conference on Engineering Education in Switzerland) will be President L. E. Grinter. He will also Represent the ECPD.

Evaluation of Engineering Education

Publication of the Interim Report of the Committee on Evaluation of Engineering Education will be followed up by requests to the Institutional Committees that they prepare reports giving their viewpoints on this report and its implementation. These will be reproduced by each institution in quantity sufficient to supply all of the engineering colleges of the country. These institutional reports will be collected and distributed by Professor Pletta. In view of this responsibility and additional activities, the board voted to continue Professor Pletta's services on a part time basis.

The Board voted to sell reprints of the Interim Report for 20¢ each in quantities less than 100 and 12¢ each for 100 or more.

ASEE Publication Board

The suggestion was made that the Secretary prepare a proposal for the formation of a Publication Board to make recommendations on all publications of ASEE.

Teaching Aids Bulletin

The question was raised as to the current status of the Teaching Aids Bulletin. The Secretary stated that this is now in the hands of the printer and that an Editorial Review Committee had been appointed to follow through on this publication. The Bulletin will be out in the Fall of 1954.

Summer Schools

The Executive Board considered ways of assisting Divisions and Committees of the Society in their financing of Summer Schools. The Board expressed the opinion that Summer Schools should be planned on a self-financing basis, which is usually possible by virtue of the fact that Summer Schools are permitted to charge a registration fee of $1.50 per day per person. However, in order to help divisions which might incur a deficit, the Board voted to recommend to the General Council that a revolving Summer School fund be set up. Deficits on Summer School operations would be paid out of this revolving fund and any excess of income over expense would be placed in the fund. The Board also requested that each application for Summer School be accompanied by an outline of the proposed program and a budget.

Summer Institutes

The Executive Board discussed the policy with respect to approval of Summer Institutes. The Board recommended that ASEE maintain authority in approving both a Summer Institute program and its budget, before it is submitted to any outside agency for financial assistance. However, after the project has been approved, the Division or the host institution sponsoring the Summer Institute would be free to seek financing and handle its own planning provided that such efforts are consistent with those presented in the proposal and are handled in a manner which will safeguard the dignity and interests of the Society.

Honorary Memberships

Although the ASEE Constitution has provision for Honorary Membership, there has never been a statement of qualifications for such membership. Because of disagreements on the qualifications for Honorary Membership, this matter was turned over to the Committee on Honorary Memberships with the request that they prepare a recommendation to present to the General Council. The Executive Board recommended that not more than two or three Honorary Memberships be granted in any one year in order to establish high prestige for this distinction.

Resolution of the Southwest Section

Two resolutions of the Southwest Section were presented. The first resolution dealt with the endorsement of a particular candidate for nomination. This resolution was referred to the Nominating Committee.

The Second resolution is as follows:

"*Whereas*, The American Society for Engineering Education is primarily and essentially an organization of engineering *teachers*, and

"*Whereas*, for some time past, the representation in the national offices has been drawn almost entirely from among the college administrators, now, therefore, *Be It Resolved*, that the Southwest Section submit to the General Council a request for a study of the feasibility of creating an additional vice-presidency which will provide representation from the college classroom teachers in the A.S.E.E. on the Executive Board of the Society by specifying that this office shall be held only by a college classroom teacher who is not an administrator."

The Executive Board requested that this resolution be referred to the Nominating Committee and to the Committee on Constitution and By-Laws.

Manual for the Annual Meeting

The Executive Board voted to approve preparation of a manual on the Annual Meeting. It was suggested that this manual be kept in loose leaf form so that it can be readily revised.

Associate Institutional Membership

The application of the Association of American Railroads for institutional membership was considered. A letter to one of the principal railroad companies indicated that their affiliation with a society such as ASEE could take place only through the medium of the Association of American Railroads. The Executive Board voted to approve the application of the Association of American Railroads but expressed the opinion that the Society should continue to seek membership among the individual companies.

Advertisements for Teaching Positions

The Board assessed the possibility of including in the JOURNAL advertisements for individuals seeking teaching positions. This was tabled for a future meeting of the Board.

Resolution of the ECRC Executive Committee

A resolution of the ECRC Executive Committee stating that they feel that no divisional meetings should be scheduled at the same time as the ECRC general session program was presented. The Executive Board felt that in general attempts should be made to minimize the conflicts of divisions and general sessions and requested that the Program Committee consider this problem in planning the program for next year.

* * *

A meeting of the Executive Board of the American Society for Engineering Education was held on June 16, 1954 in the Colonial Room of the Illini Union. Those present included L. E. Grinter, *President*, W. L. Everitt, B. R. Teare, E. A. Walker, W. C. White, *Vice Presidents*, A. B. Bronwell, *Secretary*, C. E. Watson, *Assistant Secretary*, G. W. Farnham, *Treasurer*, N. W. Dougherty, L. J. Lassalle, H. K. Work, (new officers), N. A. Christensen (guest), and M. Strohm, *Office Secretary*.

Future Annual Meetings

The Executive Board voted to accept the invitation of Cornell University to hold the 1957 Annual Meeting on its campus during the week of June 17–21.

The 1955 Annual Meeting will be held at Pennsylvania State University and the 1956 Annual Meeting at Iowa State College.

Printing Costs

The Treasurer submitted to the Board the report of the Committee on Printing Costs. This showed that the cost of printing the monthly issues of the JOURNAL would be approximately the same using the offset process as using type. However, it might

be possible to effect a saving in the cost of printing the yearbook. The Treasurer stated that he is contacting several printing firms in the South to see whether lower printing rates might be possible.

It was pointed out that a saving can be effected by arranging the pages in multiples of sixteen or thirty-two, rather than a smaller multiple.

Graduate Study Project

The proposal of the Graduate Studies Division for a survey project, to be financed by contributions from industry, was considered by the Executive Board. There was a divergence of viewpoint as to the objectives to be sought in such a study. Professor Christiansen stated that the principal purpose of the project will be to determine objectives and goals of graduate study and that although the accumulation of factual data would be necessary, this would not constitute the principal object of the study. The Board members expressed the opinion that the program should be formulated more specifically and that there should be a sharper definition of objectives before the Society should attempt to seek finances. The Board voted to recommend to the Council that a committee be appointed to formulate a specific proposal for the project. This committee would consist of officers of the Graduate Studies Division and members of the ASEE Committee on Evaluation of Engineering Education in order to establish adequate liaison with the Evaluation Committee. This action was in conformity with a similar resolution passed at the luncheon of the Graduate Studies Division. The Board further recommended that traveling expenses be provided, out of the Evaluation funds, for the Committee meeting.

Report of Committee on Society Finances

The report of the Committee on Society Finances was presented. The Board voted to adopt the recommendations of the Committee and implement these as expeditiously as possible. This resolution recommends certain investments of Society funds and also recommends, as a safety feature, that the Society seek to build up its unappropriated reserve to three-fourths of the annual operating expense.

Bank Resolutions

The Executive Board voted to authorize the new officers of the Society to sign bank resolutions, checks, and savings withdrawals.

Request of Engineering Economy Committee for Division Status

A petition of the Engineering Economy Committee for division status was discussed. The Board requested that this petition be transmitted to the Committee on Society functions with a request that this committee prepare a statement of policy relating to the formation of new Divisions and the possible discontinuance of existing Divisions which have unsatisfactory attendance. The Board further requested the Committee on Society Functions to consider the petition of the Committee on Engineering Economy as a part of this study.

ECRC Activities

Vice President Walker pointed out that members of ECRC have a natural interest in meetings of the Industrial Research Council, the National Research Council and the Conference on Management of Research. Because of these interests, there is difficulty in getting adequate interest in research activities at the Annual Meeting of the Society. This was made more acute this year by scheduled conflicts with the ECRC General Session program. He pointed out that ECRC has been requested to cooperate with other research agencies in the formation of joint meetings. The Executive Board offered two suggestions, first that ECRC cooperate with other research organizations in sponsoring joint meetings and second that ECRC invite some of these organizations to hold joint meetings in conjunction with the ASEE Annual Meeting. This would assure a sufficiently large attendance to justify outstanding programs.

Additional Matters

The following additional matters discussed at the Board meeting are reported in the Minutes of the General Council Meeting:

a. The Humanistic-Social Research Project.
b. Honorary Memberships in ASEE.
c. Report of Committee on Degree Designation.
d. Progress report on Summer Institute program.

Respectfully submitted,

ARTHUR BRONWELL,
Secretary

Minutes of the General Council Meeting

A meeting of the General Council of the American Society for Engineering Education was held in the Colonial Room, Illini Union, on June 14, 1954. Those present included: L. E. Grinter, *President;* B. R. Teare, Jr., W. C. White, W. L. Everitt, E. A. Walker, *Vice Presidents;* G. W. Farnham, *Treasurer;* A. B. Bronwell, *Secretary;* C. E. Watson, *Assistant Secretary;* J. M. Apple, H. H. Armsby, H. R. Beatty, G. P. Brewington, C. A. Brown, W. L. Collins, F. M. Dawson, M. A. Durland, E. H. Gaylord, W. P. Godfrey, H. E. Hartig, K. L. Holderman, H. K. Justice, F. Kerekes, H. Kuenzel, G. D. Lobingier, G. A. Marston, G. Murphy, E. F. Obert, R. S. Paffenbarger, G. K. Palsgrove, N. A. Parker, N. F. Rode, H. P. Rodes, Thorndike Saville, R. H. Schoonover, J. W. Shirley, E. B. Stavely, L. E. Stout, N. D. Thomas, R. W. Van Houten, R. E. Vivian, J. S. Walton, K. F. Wendt, E. R. Wilcox, C. L. Wilson, W. R. Woolrich; M. Strohm, *Office Secretary.*

Report of the Secretary

1. The Secretary reported that the Executive Board had voted to discontinue the Life Membership Fund and to transfer the funds to the general fund of the Society.

2. He also reported that the Amendment to By-Law IV had been voted favorably by 76% of the 2,283 ballots cast.

Report of the Treasurer

The Treasurer reported on the tentative annual audit. This report is included in the minutes of the Executive Board meeting of June 13, 1954.

The budget for 1954–55 (Appendix A) was presented and discussed. The council voted to approve the tentative annual audit and budget.

Evaluation of Engineering Education

President Grinter reviewed the development of the project Evaluation of Engineering Education. A preliminary report, prepared by the Committee on Evaluation of Engineering Education, drawing upon the recommendations of 88 Institutional Committees, was circulated to the Institutional Committees and Deans of engineering colleges for comment. Two proposals in the preliminary report which dealt with accreditation, namely those of bifurcation of curricula and special designation for exceptionally meritorious accreditation of curricula were almost unanimously rejected by the Institutional Committees, hence they were omitted in the later report. A meeting of representatives from industry stressed the importance of strengthening the underlying scientific background throughout the engineering program. A meeting of the full committee was held in Atlanta, Georgia, to consider some of the problems of the report. This was followed later by a two-day meeting of a small writing committee which had the responsibility of preparing the Interim Report. This Interim Report was approved by substantially all of the committee before its publication and was presented formally to the Society membership at the General Session at the Annual Meeting.

It was thought that the Interim Report should be reviewed within one year and that a final report should be prepared, based upon the recommendations of Institutional Committees. Also, the suggestion was made that each Institutional Committee be invited to prepare its recommendations relative to the Interim Report. It was suggested that these be prepared in sufficient quantity that one copy of each report be made available to the library of each engineering college in the country. These could be sent to the secretary of the Committee on Evaluation of Engineering Education for binding, together with a copy of the report.

Canon of Ethics

The General Council considered ways and means of getting the ECPD Canon of Ethics more widely accepted and used in engineering colleges. It was recommended that the Deans of engineering colleges be asked to present a copy of the Canon of Ethics to each graduating senior. The Executive

Board also voted to send suitable copies to all officers, Council members, and Deans of engineering colleges. It was pointed out that the Canon of Ethics should be presented to graduating seniors in a climate which will impress upon them its significance in their future professional outlook and work.

Humanistic-Social Research Project

The progress in setting up the Humanistic-Social Research Project, under a grant of $30,000 from Carnegie Corporation, was reviewed by Vice President White. Dr. Edwin S. Burdell, President of Cooper Union, has accepted chairmanship of the Committee on the Humanistic-Social Research Project. Dr. George Gullette, head of the Department of Social Studies at North Carolina State College, is serving as Director of the project on a part time basis. A field committee has been appointed to investigate programs in those engineering colleges in the country where considerable thought has been given to the development of suitable curricular offerings.

Summer Institutes

The progress of setting up Summer Institutes in Solid State Physics in Engineering Education and Nuclear Science in Engineering Education was reviewed. The two Summer Institutes this year are supported by grants from the National Science Foundation totaling $15,500. Each Summer Institute has been preceded by a closed conference of 20 to 30 leading authorities in the field to formulate the objectives and help to get the material clarified and organized.

Summer Institutes in Thermodynamics and Advanced Mathematics as applied to various fields of engineering, the teaching of mechanics in physics and engineering courses, and the teaching of electricity and magnetism in physics and engineering are being currently considered for 1955.

Summer Schools

The difficulties in working out the details in registration and attendance at Summer Schools this year were mentioned. This was particularly acute inasmuch as the Society sponsored six Summer Schools, whereas no more than two have been sponsored in any previous year. It was recommended that a committee be appointed to study the relationships between Summer Schools and the Annual Meeting of the Society and present recommendations for improvement. This committee would also collaborate with the committee which is preparing a manual on the Annual Meeting of the Society.

It was pointed out that divisions desiring to sponsor Summer Schools should present their proposals and budgets prior to the October 27th meeting of the General Council.

A recommendation of the Executive Board that a revolving fund be set up to underwrite the expenses of Summer Schools and that the excess of income over expense of Summer Schools be placed in this fund was defeated.

A request of the Chemical Engineering Division for a Summer School in 1955 was presented. It was suggested that the Division submit a program and budget for the consideration of the Executive Board.

A motion to send an expression of appreciation to all those responsible for organizing Summer Schools and Summer Institutes was unanimously voted.

* * *

A meeting of the General Council of the American Society for Engineering Education was held on Friday, June 18, 1954, in the Colonial Room of the Illini Union. Those present included L. E. Grinter, *President;* B. R. Teare, Jr., W. C. White, W. L. Everitt, E. A. Walker, *Vice Presidents,* A. B. Bronwell, *Secretary,* George Farnham, *Treasurer,* and Marion Strohm, *Office Secretary;* E. E. Ambrosius, H. H. Armsby, H. R. Beatty, G. P. Brewington, C. A. Brown, N. A. Christensen, A. P. Colburn, W. L. Collins, F. M. Dawson, A. Diefendorf, W. W. Domberger, N. W. Dougherty, M. A. Durland, A. J. Fairbanks, C. D. Fawcett, O. C. French, E. H. Gaylord, F. F. Groseclose, W. Hazell, K. L. Holderman, G. Hollistor, H. K. Justice, F. Kerekes, H. Kuenzel, L. J. Lassalle, E. J. Lindahl, G. D. Lobingier, G. A. Marston, J. C. McKeon, A. J. McNair, G. Murphy, R. S. Paffenbarger, G. K. Palsgrove, N. A. Parker, H. P. Rodes, Thorndike Saville, R. Schoonover, L. Z. Seltzer, J. W. Shirley, P. E. Soreson, E. B. Stavely, L. E. Stout, N. D. Thomas, R. E. Vivian, J. S. Walton, E. R. Wilcox, and H. K. Work.

EJC Amendments

The recommendations of the Executive Board meeting of June 13, relating to the proposed amendments of the Engineers'

Joint Council Constitution were discussed. The General Council voted to endorse the recommendations of the Executive Board, which is to approve all amendments except Amendment 5, relating to individual members, this amendment being tabled without prejudice for discussion at the Fall Meeting of the Council.

Proposal of the Graduate Studies' Division

The recommendation of the Executive Board meeting of June 16, 1954, to appoint a committee consisting of members of the Graduate Studies Division and of the Committee on Evaluation of Engineering Education to formulate a specific proposal for the Graduate Studies' Project was discussed and approved. Such a proposal would make it possible to solicit funds and proceed as rapidly as possible in getting the project under way.

Resolution to Dr. Grinter

Vice President White presented a resolution of appreciation to Dr. Grinter for his outstanding leadership during the past year. This resolution was unanimously adopted by the General Council.

Resolution of the Technical Institute Division

A resolution of the Technical Institute Division presented to the Council in June, 1952, was discussed. This resolution requested Society endorsement of the title "Engineering Technician" for graduates of technical institutes and also the use of an appropriate Associate degree to designate completion of work.

A committee was appointed in 1952 to study the resolution. This committee in its report in June, 1953, accepted the resolution with reservations on the use of the word "engineering." The General Council did not feel that this action was definitive enough for a vote by the Council and requested that another committee be formed to consider not only the matter of degree designations for graduates of technical institutes, but also the entire matter of degree designations, including the desirability of differentiating between the four- and five-year engineering degrees. The committee carried out correspondence during the year and held a meeting at the Annual Meeting of the Society. Dean H. K. Justice presented the report of the committee, which consisted of a vote 3 to 2 in favor of recommending adoption of the Technical Institute Division Resolution. Dean Justice stated that the Technical Institute representatives on the committee favored adoption of the resolution, whereas the engineering school representatives were opposed to it.

President Grinter stated that ECPD has accepted use of the word "engineering" as an adjective in describing technical institute curricula and graduates, but not as a noun and suggested that this might provide a way out of the dilemma. President H. R. Beatty pointed out that the ECPD had prepared specific definitions for "professional engineer" and "engineering technician" and stated that the resolution of the Technical Institute Division was in conformity with these definitions. President Rodes stated that the Technical Institute Division has tried to use terms which were clear and fair and in conformity with the practice in Junior Colleges. He stated that over 400 Junior Colleges grant the "associate degree" in other fields. He pointed out that several Technical Institutes associated with engineering colleges now grant associate degrees in engineering.

There was some question as to the desirability of leaving the title "associate degree" open-ended without specifying whether the word engineering is to be used in this title. President Rodes stated that the practice differs in various states, and therefore that it was not possible to make a specific recommendation. It was also pointed out that this problem has important implications insofar as the public is concerned, since it is necessary to adopt terminology which will not mislead prospective students. In order to help them to make correct decisions, it is necessary to delineate between the Technical Institute type of education and the engineering type of education, without prejudice to either.

Dean Saville moved that this matter be studied for another year and that the committee be expanded to include a number of different points of view. The council adopted this resolution.

Activities of Engineers' Joint Council

Dean Saville reviewed the activities of EJC, including the attempts of EJC to get engineers appointed to top positions on the Board of Engineers of the St. Lawrence Seaway Project, the activities of the Water

Policy Committee, the coming meetings of UPADI, EUSEC, and the World Power Conference, the Hoover Commission, and many others. He emphasized the active part which ASEE is taking in EJC activities.

Resolution of Technical Institute Division

The following resolution of the Technical Institute Division was presented.

"*Be It Resolved*

"That the Technical Institute Division request the approval and support of the ASEE to organize and develop with the aid of foundation funds a project devoted to the study of that part of engineering education concerned with the education and training of engineering technicians and other technical personnel who assist the professional engineer in carrying on his work.

"*Be It Further Resolved*

"That such a study and its prosecution be subject to cancellation as an independent project should the Society itself undertake a study that would encompass all phases of engineering education, including those areas served by the technical institute."

This resolution furthers the general purpose of the Society, which is to make thorough studies of education at all levels in engineering and technical institute curricula. The Council voted to adopt its resolution.

Applications for Membership in ASEE

The Council voted to approve the latest list of 130 applicants for membership in ASEE.

Delinquencies

The Executive Board voted to drop from membership 201 members owing two or more years' dues.

Life Memberships

The Executive Board voted to grant life memberships to 14 members of the Society who meet all the constitutional requirements for life membership.

Application of Engineering Economy Committee for Division Status

The Secretary read a petition (Appendix E) from the Committee on Engineering Economy requesting Division status. The Council voted to refer this problem to the Committee on Society Functions with the request that they also study the more general problem of the formation and dissolution of Divisions.

Report of the Committee on Society Functions

Vice President Teare presented a brief progress report of the Committee on Society Functions. It is expected that this committee will complete its assignment and prepare a final report during the current year. The committee is studying, among other problems, the methods of nominating officers to see if: (1) it would be feasible to require that one member of the Executive Board be selected from outside the Dean or Administrator ranks; (2) it would be possible to get more complete biographical information on proposed candidates; and (3) it would be desirable to hold the election of officers in the fall so that the incoming officers would have an opportunity to become acquainted with current Society problems and develop a program for the following year before the time of the Annual Meeting.

Associate Institutional Membership

Mr. Jesse McKeon presented a report of his Committee on Associate Institutional Membership, stating that the Society now has 111 Associate Institutional Members, whereas two years ago it had three Associate Members. He expressed the view that this could be further expanded.

Other Matters

The following are additional items taken up at the council meeting which are reported in the Minutes of the Executive Board Meeting.

a. Report of the Secretary.
b. Report of the Treasurer.
c. EJC Amendments.
d. Honorary Membership.
e. Future Annual Meetings
f. Printing costs.

Respectfully submitted,

ARTHUR BRONWELL,
Secretary

Report of the Resolutions Committee

ASEE Annual Banquet—June 17, 1954

Mr. Chairman, Ladies and Gentlemen:

For the Committee on Resolutions, comprising Colonel J. H. Belknap of the Radiation Laboratory, University of California, Dean G. F. Brannigan of the University of Arkansas, Mr. D. S. Bridgman of the American Telephone and Telegraph Company, Dean W. R. Woolrich of the University of Texas, and myself, I take pleasure in offering the following resolution:

To the University of Illinois and all members of her gracious family who planned so thoughtfully the happy arrangements for this 62nd Annual Meeting and who have been such generous and delightful hosts throughout our stay on this spacious campus, we of the American Society for Engineering Education express our wholehearted thanks. We gratefully acknowledge the excellent provisions made for our comfort, convenience, and entertainment, the high competence with which our whole program of conferences was facilitated and made both pleasant and profitable.

We wish in particular to voice our appreciation to the Officers of the University —President Morey and Dean Everitt, to Professor Lisle Rose, General Chairman of the Local Committee and to all members of his organization, including the ladies who ministered so hospitably to our families. As we return to our home communities we shall carry with us the fruitful experiences of this memorable week together with fond memories of old friendships renewed and of new friendships formed while we have been guests on this campus.

With one accord we salute the University of Illinois and our colleagues on her staff who have been such perfect hosts throughout this Annual Meeting.

Mr. President, I move the adoption of this Resolution.

Adopted unanimously.

W. C. WHITE, *Chairman*

Resolution Presented by Vice President W. C. White

Mr. Chairman:

This meeting of old and new members of the Council seems a particularly happy and appropriate occasion to voice our hearty thanks to our President, Dr. Grinter, for his devoted and highly competent leadership of the Society during the past year. He has carried not only the substantial burdens of the Presidency, but also the Chairmanship of the important Committee on Evaluation of Engineering Education whose activities have been tremendously time consuming throughout the year. Those of us here who have been privileged to work closely with him are mindful of the exhausting responsibilities involved in this dual task. We gratefully acknowledge his patience, perseverance, scholarly forward look, and the fine personal qualities that make it such a pleasure to work with him. We are deeply appreciative of the magnificent leadership which he has given to us in 1953–54.

Resolution unanimously adopted.

News of Engineers' Joint Council Activities

Engineers' Joint Council Organizes Group to Meet Nuclear Problems. 1955 Convocation Planned

To meet "the pressing problems of nuclear engineering and the related sciences," with particular interest in "industrial usefulness," Engineers' Joint Council, composed of major American engineering societies with a total membership of 170,000, today announced initial steps toward an organized program of confronting these problems "authoritatively by a group of leading engineers."

In making the announcement, Thorndike Saville, President of the Council and Dean of Engineering at New York University, commented that "action by this powerful engineering group is further evidence that nuclear energy is well on the way to having important peace time industrial usefulness."

An invitation will be extended to the societies of physicists and chemists to join the engineers in planning a strong organization, it was reported by Warren L. McCabe, Administrative Dean at Brooklyn Polytechnic Institute, Chairman of Engineers' Joint Council Committee on Recognition of Specialties in Engineering. The movement is expected to bring together most of the country's eminent participants in industrial nuclear development.

Although organization of the new group is in its initial stages, a national convocation in the Summer or Fall of 1955 is contemplated for nuclear development for industrial use. The pressing problems of nuclear engineering and the related sciences are to be dealt with authoritatively by a group of leading engineers.

In this announcement, Thorndike Saville, President of Engineers' Joint Council, is joined by Daniel V. Terrell, President of the American Society of Civil Engineers; Leo F. Reinartz, President of the American Society of Mining and Metallurgical Engineers; Lewis K. Sillcox, President of The American Society of Mechanical Engineers; Alexander C. Monteith, President of the American Institute of Electrical Engineers; Chalmer G. Kirkbride, President of the American Institute of Chemical Engineers; Dale L. Maffitt, President of the American Water Works Association; William E. Blewett, Jr., President of the Society of Naval Architects and Marine Engineers, and Nathan W. Dougherty, President of the American Society for Engineering Education. Under the general policy of Engineers' Joint Council to encourage the close cooperation of specialists in engineering, a strong joint agency will be set up to organize the cooperation of all engineering groups and related scientists to develop discussions of nuclear engineering subjects and to deal with the publication of worthwhile papers and addresses.

Engineers' Joint Council Amends Constitution to Broaden Participation

In a major action to increase the unity of the engineering profession, Engineers' Joint Council has adopted two important constitutional amendments permitting, under prescribed conditions, the admission of national and local organizations not presently meeting all the qualification for constituent membership. Conditions for admission are being drafted by a special committee.

Engineers' Joint Council at present is constituted of eight major engineering organizations with a total individual membership of 170,000. These are the American Society of Civil Engineers,

American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Water Works Association, American Institute of Electrical Engineers, Society of Naval Architects and Marine Engineers, American Society for Engineering Education and American Institute of Chemical Engineers.

The amendments were made effective by the Executive Committee on July 8, following affirmative action by each of the constituent societies. A total membership of at least 5,000 is required of a national organization to qualify as a constituent society. The first amendment permits the admission as Associates of national organizations with less than 5,000 members.

The second amendment permits the admission, as Affiliates, of societies "which are regional rather than national in geographical scope." This amendment also permits the admission as Affiliates of "federations of engineering societies (or of sections of such societies) broadly representative of the engineering profession in cases in which the majority of the societies who are members of the federation have qualifications for voting members equivalent to those required of constituent societies of the Council.

In both instances, Associates and Affiliates, the one relating to national organizations and the other to local or regional organizations, admission will be without official vote. Nonetheless, provision is made for representatives to participate in the Council's meetings.

To achieve these objectives, the Council acts as an advisory and coordinating agency to seek and study matters of mutual interest to the constituent societies and to recommend parallel action by them; represents the constituent societies in instances in which these societies desire such joint representation; administers, on behalf of the engineering profession, activities authorized by a majority of the constituent societies.

The officers of Engineers' Joint Council are: President, Thorndike Saville; Vice President, Carlton S. Proctor; Treasurer, E. Lawrence Chandler; Secretary, Stewart E. Reimel.

Do You Know—

(*Continued from page 100*)

► Again we come to a parting of the roads where we regretfully lose some of our active officers but acquire a new Executive Board to fill their mission. Our high esteem and deep appreciation go to Past President L. E. Grinter, Vice President W. C. White and Vice President Eric A. Walker who have cooperated so wholeheartedly and who helped to pilot ASEE activities to new heights of achievement during the past year. We eagerly welcome the new association with President Dougherty, Dean Lassalle and Dr. Work who have already taken a vigorous role in planning forthcoming ASEE activities.

► Mark it down now—the next Annual Meeting at Pennsylvania State University, June 20–24, 1955.

With best regards,
ARTHUR BRONWELL, *Secretary*

Officers of Divisions, Committees and Sections 1954-55

DIVISIONS

AERONAUTICAL: L. Z. Seltzer, Chairman, West Virginia University

AGRICULTURAL: R. H. Driftmier, Chairman, University of Georgia

ARCHITECTURAL: J. E. Branch, Chairman, University of Miami

CHEMICAL: R. W. Moulton, Chairman, University of Washington

CIVIL ENGINEERING: J. W. Hubler, Chairman, Washington University

COOPERATIVE ENGINEERING EDUCATION: J. G. Wohlford, Chairman, Georgia Institute of Technology

EDUCATIONAL METHODS: E. B. Stavely, Chairman, Pennsylvania State University

ELECTRICAL: J. N. Thurston, Chairman, Clemson Agricultural College

ENGINEERING DRAWING: T. T. Aakhus, Chairman, University of Nebraska

ENGLISH: T. Farrell, Jr., Chairman, University of Iowa

EVENING ENGINEERING EDUCATION: C. Schaffner, Chairman, Brooklyn Polytechnic Institute

GRADUATE STUDIES: N. A. Christensen, Chairman, Cornell University

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PACIFIC NORTHWEST: M. L. Jackson, Chairman, University of Idaho

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ROCKY MOUNTAIN: D. F. Peterson, Chairman, Colorado A. & M. College

SOUTHEAST: H. V. Flinsch, President, Mississippi State College

SOUTHWEST: V. L. Doughtie, Chairman, University of Texas

UPPER NEW YORK: N. A. Christensen, Chairman, Cornell University

Officers of the Society and Members of the General Council are listed on Page 2 of this issue.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 17, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Brooklyn Polytechnic Institute	Dec. 4, 1954	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	April 2, 1955	M. M. Jones, University of Missouri
National Capital Area	Catholic University	Oct. 5, 1954	J. C. Michalowicz, Catholic University
New England	Massachusetts Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	A.F. Inst. Wright	Sept. 17–18, 1954	K. F. Sibila, University of Akron
	University of Akron	May 7, 1955	
*Pacific Northwest	Oregon State College	Spring, 1955	M. L. Jackson, University of Idaho
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1954	B. M. Green, Stanford University
*Rocky Mountain	University of Utah	Fall, 1954	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9 1955	V. L. Doughtie, University of Texas
Upper New York	Cornell University	Oct. 22–23, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

AFZALI, SHUJAAT A. K., Head Shop Instructor, Karachi Polytechnic Institute, Karachi, Pakistan. E. R. Stapley, H. P. Adams.

AGNEW, JOHN T., Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. O. W. Witzell, J. B. Jones.

AHMED, N., Head Shop Instructor, Karachi Polytechnic Institute, Karachi, Pakistan. E. R. Stapley, H. P. Adams.

ALDINGER, L. A., Director, Education and Training, Research Laboratories Division, General Motors Corporation, Detroit, Mich. J. C. McElhany, W. E. Snyder.

ALI, MOHAMMAD S., Head Shop Instructor —Machine Shop, Karachi Polytechnic Institute, Karachi, Pakistan. E. R. Stapley, H. P. Adams.

AMERMAN, PRESTON I., Director of Employment, Detroit Edison Co., Detroit, Mich. A. R. Hellworth, C. J. Freund.

AREAUX, VIRGIL G., Assistant Professor of Mechanical Engineering, Tri-State College, Angola, Ind. A. A. Hockey, S. S. Radford.

BARTUNEK, PAUL F., Associate Professor of Physics, Colorado School of Mines, Golden, Colorado. G. W. LeMaire, F. K. Sabott.

BONNER, THOMAS W., Chairman and Professor of Physics, Rice Institute, Houston, Tex. R. J. Seeger, R. A. Morgen.

CASHION, JAMES J., Instructor Engineering, New York State Maritime College, Bronx, N. Y. J. J. Connor, Jr., J. J. Foody.

CESSNA, S. ROGER, Administrative Engineer —Technical Recruiting and Training, Major Appliances Division, General Electric Co., Buechel, Kentucky, K. B. McEachron, Jr., M. M. Boring.

CHAPMAN, HARMON M., Director of General Studies, New York University, New York, N. Y. T. Saville, H. Torgersen.

CHOLET, BERTRAM, Vice President, Higgins Ink Co., Brooklyn, New York. A. Jorgensen, C. P. Buck.

COCHRAN, STANLEY W., Manager Admission, Standards and Services, RCA, Camden, New Jersey. J. S. Morehouse, J. J. Goller.

COYNE, MARTIN A., Personnel Manager, The M. W. Kellogg Co., New York, N. Y. J. D. Constance, J. Cundelan.

CURTIS, CARROLL A., Assistant Professor of Civil Engineering, University of Idaho, Moscow, Idaho. N. F. Hindle, M. L. Jackson.

DANNER, CHARLES S., Assistant Professor of Civil Engineering, University of Illinois, Urbana, Ill. M. O. Schmidt, J. C. Huntington.

DAY, ROBERT W., Assistant Professor of Mechanical Engineering, University of Massachusetts, Amherst, Mass. G. K. Palsgrove, J. W. Bursik.

DOVE, RICHARD C., Assistant Professor T. and A. M., Iowa State College, Ames, Iowa. G. Murphy, A. R. Livingston.

EBAUGH, PAUL, Assistant Director, Engineering Research, Pennsylvania State University, State College, Pa. E. A. Walker, E. B. Stavely.

EBERT, IAN O., Associate Professor of Electrical Engineering, Michigan State College, East Lansing, Mich. R. W. Ludt, R. L. Sweet.

EKBERG, CARL E., JR., Assistant Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. J. O. Liebig, Jr., C. D. Jensen.

EVERILL, RICHARD T., Employment Manager, Carrier Corporation, Syracuse, New York. J. H. Carpenter, W. E. Renner.

FOX, EDWARD A., Assistant Professor of Mechanics, Rensselaer Polytechnic Institute, Troy, New York. C. E. Work, R. H. Trathen.

GARROTT, WILLIAM L., Associate Professor of Electrical Engineering, University of Nevada, Reno, Nev. D. V. Terrell, A. L. Chamhas.

GREEN, THOMAS F., Instructor in English and Social Sciences, South Dakota School of Mines and Technology, Rapid City, So. Dak. R. D. LaRue, E. H. Stevens.

GYAW, B. AUNG, Workshop Superintendent, University of Rangoon, Rangoon, Burma. W. L. Collins, J. O. Smith.

HART, DUANE D., Assistant Professor of Mechanical Engineering, Clarkson College of Technology, Potsdam, New York. E. McHugh, M. G. Mochel.

HART, WALTER T., JR., Captain U. S. Navy, Inspector of Naval Material, Detroit, Mich. C. J. Freund, A. B. Bronwell.

HATFIELD, THEODORE N., Chairman Department of Physics, University of Houston, Houston, Tex. R. J. Seeger, R. A. Morgen.

HAYNES, CHARLES W., Associate Professor of Engineering Mechanics, University of Nebraska, Lincoln, Nebr. E. J. Marmo, D. M. Pierce.

HECKBERT, ALBERT, I., Instructor in Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, R. H. Frazier.

HENRY, HAROLD R., Assistant Professor of Civil Engineering, Michigan State College, Lansing, Mich. J. R. Snell, R. J. Plan.

HOLLER, WALKER W., Colonel and Commanding Officer, Office of Ordnance Research, Duke Station, Durham, N. C. W. E. Wilson, C. D. Fulton, Jr.

HOYT, WILLIAM M., Coordinator of Engineering Recruitment and Personnel, International Business Machines Corporation, New York, N. Y. D. W. Orton, T. A. Marshall, Jr.

HUTCHINSON, JOHN W., Instructor in Civil Engineering, University of Illinois, Urbana, Ill. E. Danner, T. C. Shedd.

INNES, PRICE S., General Employment Manager, Reynolds Metal Co., Richmond, Va. J. W. Whittemore, A. B. Bronwell.

IRBY, HOWARD E., Assistant Professor of Civil Engineering, University of Missouri, Columbia, Mo. M. O. Schmidt, J. R. Matlock.

JACKSON, J. ROY, Director of Guidance and Placement, Pittsburgh Technical Institute, Pittsburgh, Pa. W. I. Short, R. F. Edgar.

JIJI, LATIF M., Instructor in Mechanical Engineering, University of Toledo, Toledo, Ohio. E. W. Weaver, Jr., G. L. Heath.

KHAN, SHAFAAT U., Head Shop Instructor Automobile, Karachi Polytechnic Institute, Karachi, Pakistan. E. R. Stapley, H. P. Adams.

KILLIAN, THOMAS J., Dean of School of Engineering and Architecture, Catholic University of America, Washington, D. C. W. E. Wilson, C. D. Fulton, Jr.

KLINE, DAVID F., Engineer Guided Missiles Dept., General Electric Corp., New York. W. H. Branch, R. W. Porter.

KOENIG, JOHN H., Director, School of Ceramics, Rutgers University, New Brunswick, N. J. M. T. Ayers, A. J. Del Mastro.

KOROLENKO, VLADIMIR G., Instructor in Mechanical Engineering, Syracuse University, Syracuse, N. Y. J. A. King, R. A. Galbraith.

KULT, MILTON L., Assistant Professor of Electrical Engineering, University of Akron, Akron, Ohio. P. O. Huss, K. F. Sibila.

LAFORGE, ROBERT M., Associate Professor of Industrial Engineering, University of Tennessee, Knoxville, Tenn. J. R. Shobe, A. T. Wood.

LANDALL, LEONARD B., College Relations Co-ordinator, Raytheon Manufacturing Co., Waltham, Mass. W. C. White, R. L. Wooldridge.

LEONARD, GEORGE D., Instructor Industrial Arts, Fenn College, Cleveland, Ohio. N. Rimboi, W. A. Patterson.

LIMA, PAULO R., Professor of Engineering Drawing, University of Brazil, Rio de Janeiro, Brazil. D. P. Adams, A. S. Levens.

LONG, V. ALLEN, Professor and Head of Physics Department, Colorado School of Mines, Golden, Colorado. G. W. LeMaire, F. K. Sabott.

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MAKAR, OREST, Associate Professor of Engineering Department, St. Louis University, St. Louis, Mo. J. P. Dietzler, V. J. Blum.

MAKENS, ROYAL F., Professor of Chemistry, Michigan College of Mining and Technology, Houghton, Mich. W. C. Polkinghorne, G. W. Swenson.

MARCINELLI, ALFRED F., Instructor of Mechanical Engineering, Erie County Technical Institution, Buffalo, N. Y. J. E. Shenton, R. R. Dory.

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MILLER, JOHN C., Instructor in English, Virginia Military Institute, Lexington, Va. W. E. Byrne, S. M. Heflin.

MO, SUNGSHEN, Assistant Professor of Mechanical Engineering, Antioch College, Yellow Springs, Ohio. D. McGregor, R. W. Voelker.

MOORE, A. DONALD, Assistant Professor of Electrical Engineering, University of British Columbia, Vancouver, B. C. J. A. Merchant, J. M. Pettit.

MORRIS, RICHARD E., Instructor in Engineering Drawing and Design, Alabama Polytechnic Institute, Auburn, Ala. R. G. Sturm, J. E. Hannum.

NISBETT, STUART L., Senior Instructor in Industrial Engineering, General Motors Institute, Flint, Mich. H. M. Dent, L. C. Lander, Jr.

PECHET, MELEO S., Consulting Engineer, Prince George, B. C., Canada. J. Daniels, J. I. Mueller.

POLLARD, JAMES J., Professor of Architectural Engineering, University of Texas, Austin, Tex. P. M. Ferguson, W. R. Woolrich.

PROSSER, RAYMOND A., Supervisor of Technical Education, Board of Education, Buffalo, N. Y. L. Mitihice, L. A. Emerson.

QURAISHI, MUHAMMAD I., Workshop Superintendent, Karachi Polytechnic Institute, Karachi, Pakistan. E. R. Stapley, H. P. Adams.

RAMSEY, LOGAN C., Executive Vice President, Spring Garden Institute, Philadelphia, Pa. E. W. Watson, E. M. Williams.

REDMAN, W. CHARLES, President, Fournier Institute of Technology, Lemont, Ill. J. C. Boyce, L. A. Turner.

SAKALY, JOHN E., Assistant Professor of Mechanical Engineering, Loyola University of Los Angeles, Los Angeles, Calif. D. E. Whelan, Jr., A. R. Joyce.

SANDEL, JACK A., Instructor in Civil Engineering, University of Tennessee, Knoxville, Tenn. E. S. Fabian, A. T. Granger.

SCHAD, CHARLES R., Assistant Director of Research, Caterpillar Tractor Co., Peoria, Ill. W. C. van Dyck, R. T. Mees.

SCHEIBE, ELMER H., Associate Professor of Electrical Engineering, University of Wisconsin, Madison, Wis. T. J. Higgens, J. C. Weber.

SCHOELLER, WILBUR C., Professor of Civil Engineering, Lamar State College of Technology, Beaumont, Tex. G. B. Tims, Jr., L. B. Cherry.

SHOWERS, RALPH M., Associate Professor of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. J. B. Brainerd, H. Sohon.

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SKUBIC, LOUIS G., Assistant Professor of Engineering Drawing, Michigan College of Mining and Technology—Sault Branch, Sault Ste. Marie, Mich. B. N. Stough, H. L. Crawford.

SOO, SHAO-LEE, Assistant Professor of Mechanical Engineering, Princeton University, Princeton, N. J. W. E. Reaser, F. A. Heacock.

SPUHLER, HAROLD A., Associate Professor of Electrical Engineering, Texas Technological College, Lubbock, Tex. T. B. Stenis, C. C. Perryman.

STOCK, WILFRED A., Instructor in Mathematics, Purdue University, Calumet Center, Hammond, Ind. J. C. Rapalski, H. A. Williamson.

THOMAS, GEORGE B., JR., Associate Professor of Mathematics, Massachusetts Institute of Technology, Cambridge, Mass. W. E. Restemeyer, J. W. Cell.

THOMPSON, JOHN J., Manager, Personnel and Training Dept., Worthington Corporation, Harrison, N. J. R. S. Sherwood, R. M. Watson.

THRELKELD, JAMES L., Associate Professor of Mechanical Engineering, University of Minnesota, Minneapolis, Minn. R. C. Jordan, A. B. Algren.

VARGO, JOSEPH E., General Manager and Educational Director, Universal Scientific Equipment Sales Co., Takoma Park, Maryland. V. E. Neilly, A. P. Powell.

WAH, THEIN, Assistant Professor of Civil Engineering, Lehigh University, Easton, Pa. L. J. Goodman, E. K. Muhlhansen.

WATSON, ALFRED J., Photogrammetric Engineer, American Blueprint Company, Inc., New York, N. Y. M. J. Bergen, W. L. McCabe.

WATSON, WILLIAM W., Professor of Physics, Yale University, New Haven, Conn. W. J. Wohlenberg, R. J. Seeger.

WEBER, ALFRED H., Director, Department of Physics, Saint Louis University, Saint Louis, Mo. R. A. Morgen, R. J. Seeger.

WEBER, ARTHUR W., Director of Engineering, Corning Glass Works, Corning, N. Y. J. A. Hrones, C. E. Arnold.

WHITMER, CHARLES A., Professor of Physics, Rutgers University, Highland Park, N. J. E. C. Easton, R. J. Seeger.

WILLIAMS, RALPH M., Assistant Professor of Engineering Education, Michigan College of Mining and Technology, Houghton, Mich. R. A. Good, K. Heafield.

WILLIAMSON, ROBERT C., Head and Professor of Physics, University of Florida, Gainesville, Florida. R. A. Morgen, R. J. Seeger.

90 new members elected this year

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTOR: TO TEACH ENGINEERing drawing and descriptive geometry, Wayne University, Detroit 2, Michigan. Appointment to begin February 1, 1955. Bachelor of Science degree in Engineering and some teaching experience preferred. Opportunity to do graduate work while teaching. Submit resume of education and experience to Professor Ralph T. Northrup, Head of Department of Engineering Drawing.

Do You Know—

► You will be interested in the following resume of current activities of two of our Councils—the Engineering College Research Council and the Engineering College Administrative Council. Both Councils have been exceptionally active during the past year and have in progress some studies of considerable importance to the Society and to engineering education.

► The Engineering College Research Council—Dr. H. K. Work, Vice President—is undertaking again this year to make a comprehensive tabulation of research projects in engineering colleges throughout the country in preparation for publication of the ECRC *Review of Current Research*. This volume has proven of inestimable value to government agencies, to industry, and to the engineering colleges in helping them to identify institutions which have particular research capabilities.

► The ECRC is currently considering the possibility of establishing an award to provide recognition and incentives for distinguished research, achievements and contributions to the administration of research.

► The ECRC has completed a study on Remuneration Policies in Research. This deals with some of the knotty problems in research administration, such as, should a faculty member who is carrying research on an overtime basis receive supplementary compensation? The results of this survey will be published in a forthcoming issue of the JOURNAL.

► Also, may we call your attention to the statement on research policy published in the October issue of the JOURNAL? This was a carefully formulated policy statement of the need and objectives of research in engineering colleges.

► ECRC is currently planning a publication, *Creativity in Research*, including a number of exceedingly interesting papers on this subject presented at the ASEE Annual Meeting at Urbana and also at the joint meeting of ECAC–ECRC in the fall of 1953. This is a lively subject and one which merits thoughtful attention.

► A committee of ECRC has been doing an outstanding job of keeping research directors and deans appraised of current government policies with respect to the administration of government sponsored research. Government policies vary widely, hence the strategic importance of this service. Dean Eric Walker, the retiring ASEE Vice President and his ECRC Secretary, Virgil Neilly, have contributed a great deal of stimulus to the ECRC program during the past two years.

► The Engineering College Administrative Council—W. L. Everitt, Vice President—has vigorously undertaken a number of important new projects during the past year. An interesting project which ECAC is struggling with, and one which shows considerable promise, is a study of problems involved in getting work experience for foreign students in this country. Because of security regulations, social prejudice, language difficulties, and other factors, it is extremely difficult for foreign students to get work experience in American industry. Yet, this is one of the most valuable experi-

ences which they can obtain. There is no simple solution to this problem, but it is one deserving of careful study.

► The ECAC has been of considerable help to the Foreign Operations Administration of the U. S. State Department in advising them on cooperative arrangements which they might make with American engineering colleges in a joint effort to obtain technical assistance for underdeveloped countries of the world, particularly on problems relating to engineering education and research.

► The Manpower Committee of ECAC is continuing to work with the Engineering Manpower Commission on studies of the current status and trends of Manpower.

► During the past year, the Military Affairs Committee of ECAC conducted two studies on important current problems. One of these studies was to determine the viewpoint of deans of engineering colleges as to the desirability of protesting abrupt changes in airforce regulations governing the awarding of commissions. The second was a study to determine the viewpoint of the deans with respect to the Army ROTC move toward the Branch General Program. Both of these studies helped to clarify the issues involved in ROTC programs.

► The ECAC has just recently completed a study of engineering faculty salaries, using statistics collected by the Engineers' Joint Council. The report is published in this issue of the JOURNAL.

► The ECAC Committee on Secondary Schools has been working on a program of articulation of high school and college educational programs, with a view toward getting secondary schools to recognize the importance of this problem.

► The Selection and Guidance Committee of ECAC has been working actively with the Educational Testing Service in devising tests to assist engineering graduates to determine their individual aptitudes. These tests will also be helpful to industry in placing graduates in positions for which they are best qualified.

► The ECAC has been considering some problems relating to financial support for engineering including industry's viewpoints toward various kinds of college programs which might merit financial support. Another phase of industry-college cooperation which the ECAC is currently studying is that of exchange programs between industries and colleges, making it possible for college teachers to obtain employment in industry.

► No review of ECAC–ECRC activities would be complete without mention of the very stimulating Fall Meeting in 1953, dealing with the general theme of Creative Thinking in the Arts, in Literature, and in Engineering, or of the Joint Dinner of ECAC–ECRC which highlighted their activities at the Annual Meeting at Urbana, featuring Dr. Lee DuBridge.

► Plan now to attend the next Annual Meeting, June 20–24, 1955 at Pennsylvania State University. We'll see you there.

Respectfully submitted,
ARTHUR BRONWELL, *Secretary*

Relations with Regional Accrediting Associations*

By HAROLD L. HAZEN

Dean of The Graduate School, Massachusetts Institute of Technology

In a companion paper the principles and operations of the ECPD Accreditation Program were presented in some detail. However, ECPD is not alone in this accreditation field, as our associates in university administration are quite aware, and this has implications for the ECPD program. It appears indeed that accreditation of curricula at the college level has become a popular indoor sport that threatens to involve college presidents in a full-time activity. Surprisingly enough, college presidents are under the illusion that they have a certain minimum of other obligations and have shown signs of rebellion at what in the vernacular might almost be called a "racket."

More seriously, the threatened limitations imposed on a university by the great number of organizations claiming accreditational jurisdiction, by the quite arbitrary and unreasonable criteria that are sometimes applied to determine accreditability, and most seriously, by the resulting threat of unhealthy restraint upon educational experimentation and upon the response of the institution to its own peculiar objectives and intrinsic institutional character, are very real. In combination they have caused a rebellion against accreditation on the part of many institutional heads as expressed in the National Commission on Accrediting.[1]

The apparent abuses and unhealthy restraints had reached such proportions that the initial objective of NCA was very simple: eliminate accreditation. The radical character of this step is perhaps a significant measure of the degree of provocation involved. Subsequently the legal needs for accreditation in certain fields were recognized, as were the vast differences between the provocative, and indeed almost blackmail policies of certain proprietary groups on the one hand, and on the other hand, the work of responsible agencies of some of the professions, attempting to assure on behalf of the public a minimum standard of educational experience as preparation for a professional career. The next step was to attempt to achieve relief from what had become excesses in the accreditation activity as a whole, and to relieve the institutions from the undue demands for time and work by achieving a simplification of procedures and consolidation of efforts.

Thus during the year 1952 it was suggested that the so-called "regional associations" of colleges and universities be assigned the responsibility on behalf of

* Presented at the ECAC Conference ASEE, June 16, 1954, University of Illinois.

[1] The paper by Dr. Ewald B. Nyquist, Chairman, Commission on Institutions of Higher Education, Middle States Ass'n of Colleges & Secondary Schools, "National and Regional Developments in Cooperative Evaluation and Accrediting Activity," JOURNAL OF ENGINEERING EDUCATION, Vol. 44, No. 9, May 1954, pp. 533–538, describes the National Commission on Accrediting. It also treats regional and professional accrediting agencies and their interrelations, but with different emphases, such that the Nyquist paper and this paper are complementary rather than overlapping.

NCA for simplification and rationalization of the accreditation activity on the part of at least those professions in whose practice the public welfare and safety are involved. The regional associations were therefore thought of as a coordinating agency under which possible cooperative and collaborative operation with the accreditation agencies of certain professions might be developed.

At this point, the Middle States Association of Colleges and Secondary Schools, being the regional association with the most fully developed accreditation activity, proceeded to accelerate the process of its development along the foregoing lines. Since 1947, this Association had made institutionwide evaluations employing at appropriate times representatives from the whole professional galaxy; until 1952, however, the Middle States Association had not entered into formal cooperative agreements with professional accrediting agencies. The Engineers can, perhaps, take justifiable pride as the first professional group to consummate an agreement which would in practice explore this new collaborative principle.

During the winter of 1952–53 representatives of the Middle States Association and ECPD held a number of exploratory sessions, during which the possibilities of collaboration appeared sufficiently promising to justify an experimental operation on an actual institution. A combined questionnaire was devised and tentative agreement reached upon the roles that representatives from the two agencies would play and the reporting responsibilities of the two groups.

Differences in Function

Here it is appropriate to delineate the differences in function and in accreditation procedures of the Middle States Association and ECPD.

The objectives of the Middle States Association program can perhaps best be stated in terms of a few sentences extracted from its "Standards for Accreditation" adopted November 1950. I shall try to pick these few sentences from a several page text in such a way as to avoid as far as possible distortion of meaning through omission of context:

> The Middle States Association of Colleges and Secondary Schools is a membership of educational institutions joined for mutual encouragement and helpfulness. . . . The Association, through its Commission on Institutions of Higher Education, maintains a list of higher institutions that have been evaluated and found qualified for membership in the Association. An evaluation for initial accreditation is made at the voluntary request of the institutions seeking the approval of and membership in the Association. . . .
>
> The Commission believes that a fundamental criterion of excellence in an institution is found in the extent of the awareness of all concerned with it, of its place and importance in relation to its students, its supporters, and the community at large. . . .
>
> The deciding factor in the determination of whether any institution is qualified for membership in the Association is evidenced by the extent to which that institution fulfills the objective it has set for itself. . . .

MSA approves or disapproves the institution as a whole. It reports to the institution on the strengths and weaknesses found in the inspection. It may, for example, approve an institution for membership in spite of certain weak areas, provided the institution as a whole is achieving a reasonable degree of success in attaining its declared objectives.

As we know, the objectives of ECPD inspection are somewhat different. The objective of ECPD is to determine whether certain specific curricula individually submitted by the institution for ECPD appraisal meet the minimal standard for educational opportunity offered to students receiving its first degree in engineering.

A principal objective of MSA is the rendering to the institution of a comprehensive report on its observations of the institution's operations. This includes sections specially prepared by ECPD in

accord with MSA objectives on the engineering school as a whole, including, for example, any graduate, or non-degree work offered. The ECPD full reports, on the other hand, apply only to the curricula submitted for accreditation, and are confidential with the inspection committee, the Education Committee, and the Council of ECPD. The institution receives an official notification of ECPD action on the curricula submitted for inspection, together with a brief statement of observations by the visiting committee. The president is told that he may obtain a somewhat fuller statement upon request to the regional chairman.

As a result of the joint planning of MSA and ECPD and concurrence by the college, an experimental joint and collaborative visit was made in March 1953 to an institution that from the point of view of number and range of objectives was fairly simple in contrast, for example, to a full university. This experiment was considered a success and set the pattern for several subsequent collaborative inspections. Some of these involve much more complicated institutions and included accreditation groups from a number of other professions in addition to engineering.

The Middle States Association team includes members of recognized standing in their fields from sister institutions who are professionally active in essentially every phase of the activities of the institution being visited. It will therefore include such persons as a college president, a fiscal officer, a librarian, a superintendent of buildings and grounds, an athletics director, an admissions officer, perhaps a dean of students, a graduate dean, and in addition one or more professors or deans for each of the principal academic departments or units within the institution being visited.

The ECPD members of the visiting team perform in a dual capacity. On the one hand they do essentially the same job that they would do if they were visiting the institution alone, particularly with respect to the major engineering departments for which the institution has requested ECPD examination. On the other hand, the ECPD members function also as members in full standing of the MSA team, supplying to MSA its entire appraisal of the engineering departments. The MSA visitors in turn, either alone or in some cases jointly with ECPD members, visit and supply an appraisal to ECPD of such fields as the Humanities and Social Sciences, the basic sciences, Administration, Library, Admissions, and other areas supporting the engineering activity.

Broader Foundation of Expert Appraisal

From the point of view of ECPD this collaboration provides a substantially more thorough and expert appraisal of the non-engineering aspects of the institution's operations than ECPD alone would obtain. In a collaborative visit the ECPD team can therefore concentrate more attention on those areas in which it is expert. Thus the ECPD recommendations from such a collaborative visit have a substantially broader foundation of expert appraisal than would otherwise be available.

On the other side, some time of ECPD team members is spent in the executive sessions held each evening to review the progress of the appraisal on matters that have minor relevance to ECPD objectives. On the whole, however, it appears that the collaborative procedure provides a foundation for judgment as to the adequacy of the engineering curricula that is substantially broader than that provided by an isolated ECPD operation.

The combined questionnaire answered by the institution has two parts: the first, Part A, is general, applying to the institution as a whole, its policy, administration, budget, promotion and retirement plans, etc. The second, Part B, relates specifically to the professional area involved, in the case of ECPD, to engineering. This more comprehensive

questionnaire, all of which is available to every member of the team including ECPD members, provides much more comprehensive information, and simultaneously a fairly large amount of material not directly relevant to ECPD appraisal. The combined questionnaire presumably does offer some saving in time and effort to the institution.

In the case of a large and complex institution such as a university, a collaborative visit, including the regional association, plus as many as a dozen or two professional agencies, yields a large and potentially cumbersome group to do business in executive session. Thus far such a group, which has amounted to as many as 60 persons, has not proved unmanageable, but it is believed that continued examination of the mechanics of an inspection can result in a more efficient use of everyone's time.

While it is too soon to draw conclusions, it appears that this collaborative procedure is well worth further development. It appears to work well in the case of relatively simple institutions. It works well, but perhaps less efficiently in the case of very complex institutions. It probably saves the institution time, effort, and consequently money.

It is, I believe, generally recognized that of the regional associations the Middle States Association has developed its accreditation program much further than the others. It has an experienced, well organized, and smoothly functioning organization for this purpose, The Commission on Higher Education.

This operation is of necessity costly, simply because it is a comprehensive and thorough job. However, the costs for an institutionwide evaluation under collaborative procedures are very little if any more than if all of the professional agencies and the Middle States Association went their separate ways. The costs are perhaps more obvious since they all come at one time, not on the installment plan, as it were, but their annoyance value may be less. Direct costs can be estimated as to order of magnitude in terms of a few to several tens of people traveling to and living at an institutional location for three or four days.

Some of the other regional associations have had relatively little experience in this type of operation, and their memberships apparently do not have enthusiasm for as thorough and consequently as costly an operation as is accepted by members of the Middle States Association. How collaboration on the part of ECPD will function in a substantially less well developed activity is an open question. This is one of the current problems.

Larger Issues

There are also some larger issues that are far from completely resolved. Some institutional presidents quite rightly feel that they, with the support, counsel, and guidance of their Boards of Trustees and of their faculties, have the ultimate responsibility for the welfare and character of their institution. As a result of experience with some agencies claiming accreditational jurisdiction that have applied distinctly rigid and not always rational criteria for acceptability, these institutional presidents have very real concern lest their freedom to experiment, to develop their institution in terms of its particular function and its ideals, be unreasonably and seriously curtailed. They believe that the institution itself holds the real responsibility for pioneering and for setting patterns in the educational field. They believe that the educational institutions particularly have the responsibility for developing new ideas, experimenting in unconventional directions, and in encouraging today's radical innovations, some of which may be recognized in years to come as major advances in our intellectual growth. They believe that any authority for institutional standards assumed on the part of outside agencies without the corresponding responsibility for achieving sound results is unwarranted and unsound authority.

I doubt that any of us can disagree very seriously with these rather fundamental ideas. Yet certain implications of the concept of *noblesse oblige* may be involved in their attitude and responsibility toward accreditation activity.

On the other hand, government is recognized as properly responsible for protecting the public against incompetent professional practitioners, or those who fraudulently assert themselves to be such practitioners. Thus registration of members of professions appears to be an inevitable fact. Assurance of adequate minimum educational experience as a prerequisite preparation or component of preparation for professional practice is important. Thus it appears inevitable that some kind of safeguard against unjustified recognition of inferior educational opportunities offered to students be achieved. The real problem therefore lies in achieving means of drawing that fine line between assurance of adequate standards on the one hand, and imposing unhealthy, and in the long term, unsound educational restraints on our vigorous and experimentally-minded institutions on the other.

These are some of the problems before those who accept responsibility on behalf of their professions for accreditation activity. They share these problems with governmental registration bodies on the one hand, and with educational institution administrators on the other. The evolution of a sound and wise answer to this rather complex situation with its demands and with its hazards offers opportunity for all the wisdom and statesmanship that we as engineering educators can provide.

College Notes

The appointment of Harold Ellithorn as Head of the **University of Notre Dame's** Department of Electrical Engineering was announced recently. He will replace John A. Northcott who resigned for reasons of health. Professor Ellithorn is a specialist in network theory.

The union of industry and the **University of Michigan's** College of Engineering is anticipated under the terms of a broad program being launched by the University. Known as the Industrial Program, the plan is designed to open direct channels of communication between the College and industry, and to bring about greater understanding and cooperation between the two.

Under the program, subscribing industries will receive information on the College's latest engineering and scientific advances at nominal cost, and University and industrial experts will meet periodically to review their mutual fields of interest.

New laboratories dedicated to the fundamental research which will exploit the vast peacetime potential of electronic and nuclear science will be built as the **Massachusetts Institute of Technology's** memorial to the Institute's late chairman, Karl Taylor Compton. James R. Killian, Jr., President of M.I.T., speaking at an Institute-wide convocation in commemoration of Dr. Compton, announced plans for building the Karl Taylor Compton Laboratories for Nuclear Science and Electronics.

Engineering Ethics—From the Viewpoint of Industry*

By GERRY E. MORSE

Vice President in charge of Industrial Relations, Minneapolis-Honeywell Regulator Company

Engineering ethics, from the viewpoint of industry, are of steadily increasing importance. The gain is in proportion to the growth in the depth and complexity of the technology of industrial processes, products, and product application.

The development of modern industrial technology, which has produced a steady rise in living standards through more and better things for more people, has also brought along with it a management problem that almost did not exist 40 or 50 years ago. This is engineering in industry.

A half century ago the invention, development and application of new products were largely in the hands of the lone inventor and the gadgeteer. Edison, Eastman and Ford are examples that come readily to mind. Similarly, Minneapolis-Honeywell owes its start to a relatively simple mechanical damper control invented by a tinkerer named Al Butz. Butz' idea was to have a temperature sensing device in the house that would open and close the dampers on the furnace in the basement, and thus eliminate a lot of running up and down the cellar stairs. So, on a rule of thumb, trial and error basis, he applied in rather crude fashion some relatively simple scientific principles to achieve this end.

Today in our Company, which we characterize as "First in Controls," about one in every 10 employees is in engineering or research activities. Our development along this line is not unique. Its parallel, to a greater or lesser degree, is to be found in most manufacturing companies. When we consider that today roughly two-thirds of our total of approximately 400,000 engineers are employed in industry, it is apparent how rapidly this aspect of industry has developed.

The modern industrial product is in many cases a highly complex device in itself, and almost without exception is produced by a highly complicated process. The design of the product and the means for producing it are no longer alone in the hands of the gadgeteer or even of the practical manufacturing man. A modern industrial organization depends on highly talented and trained professional engineers and scientists for the technical aspects of its work. It must employ them in relatively large numbers. Without them it could not exist.

The engineer in modern industry works in areas that are close to the very core of management decision. The engineer is responsible for the technical development of the products, processes and customer applications on which the success of the business depends. His ability to create, test, control, and improve the product, and the soundness and practicality of his professional judgments are important elements in determining the fortunes of the organization. Because the organization is dependent upon him, and because he is entrusted with a responsibility that others in it can not do

* Presented at the Annual Meeting of ASEE, Relations With Industry Division, University of Illinois, June 15, 1954.

or often can not even check, it is essential that the engineer be clearly aware of the ethical requirements of his profession.

While questions of ethics may arise in any interpersonal relationship where one puts himself or his fortunes in the hands of another, they tend to be most serious when professional service is involved. Two basic elements in the professional relationship are responsible. First, a profession is distinguished from a skill or a craft, no matter of how high an order the latter may be, by the degree of subjectivity involved. The professional goes beyond a routine, a formula, or an established habit pattern. He is sensitive to the uniqueness of each situation. His results are not predictable in terms of time or effort but flow from his individual and independent discretion and judgment. He alone knows with what understanding, competency, and likelihood of success he approaches the assignment. Ethically, he has the responsibility to advise his client or employer if other help is required. Parallels are observable in other professions. For example, the clergyman may advise the help of the doctor or the psychiatrist, the physician may advise calling in a specialist, or the jurist may advise his own disqualification from a case.

Second, the professional is characterized by the specialization of his aptitude, education, and experience. He knows and can do what the non-professional does not know and can not do. In professional matters the non-professional is almost completely and blindly dependent on him. Ethically, therefore, he has the responsibility to protect his client or employer and the client's or employer's interest. Parallels are observable in other professions. For example, the teacher may advise against further study because lack of aptitude makes it a waste of time, effort and money, or the lawyer may advise dropping a suit because further prosecution of it would simply drain away his client's or employer's funds.

The True Professional Does Not Trade Dishonestly Upon Ignorance

Both of these aspects of the ethics of engineering, or of any profession, may be summarized in the concept that no intentional, and insofar as possible no unintentional, unfair advantage is to be taken of the client, employer or user. Or, to say it another way, the true professional does not trade dishonestly upon the ignorance of others.

Ethics is largely an individual matter. The ethics of an organization or of a group tends to be simply an integration of the ethics of its members. It is from this point of view that we approach the question of ethical practice in the engineering profession as it relates to collective bargaining. It is not reasonable to say that membership in a collective bargaining organization in itself alone, constitutes a breach of ethics for the individual engineer. Nor is it sound to make a charge of unethical practice on the part of engineering unions except in specific cases where such lack of integrity on their part has actually taken place. Experience to date seems to support the hope that we can have enough faith in engineers as individuals to expect that unethical practice will be found to be one of the least important faults of engineering unions. There are aspects of the problem, nevertheless, which do warrant our study and concern.

Let us review the historical background of the collective bargaining movement among engineers. After the passage of the Wagner Act in 1935, some engineers and other professional employees were, against their will, being forced into labor organizations composed predominately of non-professional employees. Theoretically, engineers were free to form collective bargaining organizations of their own, or free to deal as individuals. In cold reality they were at a disadvantage because of the NLRB practice of including them in larger units. In such cases, because of their relatively smaller numbers compared with other non-supervisory

office or factory employees, they found themselves outvoted in representation elections and included in general factory or office bargaining units. In 1937, ASCE formed a "Committee on Unionization" to study the problem. Despite ridicule and scorn, ASCE pressed the study and by 1944 had developed a plan under which engineers seeking to organize could receive guidance. Then, in 1947, through the combined efforts of ASCE and the other constituent societies of the Engineers Joint Council, the so-called "professional employee" provisions were written into the Labor-Management Relations Act, commonly referred to as Taft-Hartley. The Act, as you know, guarantees professional employees the right to decide whether they will form a labor organization of their own, be included with a non-professional labor organization, or deal with their employer on an individual basis. It was during this hectic period that most of the present day engineering collective bargaining units were established.

Although we cannot know for certain what was in the minds of those of the engineering profession who were instrumental in creating and developing collective bargaining organizations of professional employees, most of them said on the one hand they were trying to prevent being included in units with non-professionals and on the other hand that they foresaw the development of organizations of professional employees for collective bargaining purposes which would bee different in character from the typical labor union. They made the fundamental error of assuming that a collective bargaining relationship between a group of professional employees and management could be very cordial and dignified and that problems would be solved forthrightly without resort to the exercise of power or the strategical and tactical maneuvering of the typical collective bargaining situation. Nor is it likely that they foresaw—there is no reason to suppose they had the necessary understanding or experience to do so—that an engineering union or any organization that engages in collective bargaining must inevitably adopt the typical tactics, practices, and characteristics of the trade union.

My experience in collective bargaining convinces me that it is inevitable. Any organization formed for the purpose of collective bargaining, because of the very nature of the demands of its membership upon it and their reaction to its accomplishments on their behalf will sooner or later be forced to resort to the traditional practices of the typical labor union. There is a clearly observable trend by the engineering collective bargaining organizations of movement in this direction. Those of you who have been following the published reports are aware of it. For example, you see it in the behavior of the collective bargaining organizations representing the engineers of some of the West Coast airplane manufacturers, of some of the electronics companies in the New York city area, and of Minneapolis-Honeywell here in the Midwest.

You see extravagant demands, heated and protracted negotiations, costly strikes, the creation of a national organization, the Engineers and Scientists of America, to extend collective action beyond the scope of the local unit, and action in concert with unions that represent non-professionals.

Observable Trends

Some other observable trends within engineering collective bargaining organizations deserve attention. First, the average or better than average engineers, or the ones who really understand the individual and professional nature of engineering work seem to become apathetic toward collective bargaining. They seem to sense on the one hand the inevitable danger of the tendency of group action to result in "leveling down" and find they can get better job satisfaction, better advancement, and better pay on the basis of their own individual effort than on a group basis. They lose interest in the

collective bargaining approach and so do not furnish the stability and leadership qualities to the group that they might if they participated more actively. Second, those of the collective bargaining organizations that have heterogeneous memberships composed of engineers and non-professionals are tending to develop an internal divergence of views and aims. The very fact that the work of the non-professionals lends itself more readily to standardization and the members of the group to more easy interchange makes collective action of interest to them and a more satisfactory experience. Thus, even if they are a minority, their views and power tend to become dominant in the collective bargaining activity. Finally, there is the noticeable restriction on communication between management and the engineer where a collective bargaining representative is selected by the engineers to replace them in dealing with their employer on wages, hours, and other conditions of employment.

For all of these reasons there is a very serious question in my mind as to the compatibility of collective bargaining and engineering. There is, I believe, a fundamental conflict between the practices inherent in collective bargaining and the kind of unregimented atmosphere that must prevail in an engineering organization if it is to function professionally and accomplish the results for which it is employed. An employer does not hire an engineer in the same sense he hires a janitor, an assembly man, a truck driver, or a tool and die maker. He selects the engineer as a professional, just as he would select his own doctor or lawyer. He is interested in more than technical competence, education, and previous experience. Because he is putting his fortunes into the hands of the engineer insofar as he must rely with complete confidence on the engineer's professional opinions and actions, he is intensely interested in the engineer as a person. Just as a clergyman can not effectively serve his parishioners unless there is a freedom of communication and sympathetic "ease" between them, or a teacher cannot effectively lead his students to learning unless there is a mutual respect, confidence, and interchange of ideas, so the engineer can not fill his place in the industrial organization unless he has the right personal "fit." At Minneapolis-Honeywell, for example, we find it necessary to interview about 100 engineers to find 10 whom we feel we should consider for employment. Of the 10 on whom we spend the time, effort and money for testing, for multiple interviews, and for visits to our plants, we make actual offers to about 6. Of the 6, only 2 or 3 accept and are hired. A similar, although less easily observable selection, takes place in our assignments of work and position advancements of engineers.

A tendency to obscure the professional and highly individual character of engineering employment has resulted from the popularization in recent years of the idea of team-work within the industrial unit. While the engineer is on one hand a member of the team together with managerial, financial, manufacturing, sales, and all the other employee groups that make up the typical company, he remains, on the other, essentially an individual insofar as his professional responsibility is concerned. Even in a department of hundreds of engineers the fundamental reason for their employment and the requirements of their work remain unchanged. Professional problems are solvable only by individuals. Others may help to stimulate the individual, different approaches may be tried by different individuals simultaneously, sub-professionals or non-professionals may aid through supplying related, supplemental, or directed services, but in the absence of successful individual effort and accomplishment, the term, or committee, or organization will fail. It is at this point that the incompatibility of professionalism and collective bargaining stands out sharply.

Impact Upon Engineers

Those of us who have had experience in collective bargaining with engineers have seen the impact that it has upon them. Collective bargaining is a process of give-and-take, of argument, of compromise. In other words, it is collective and it is bargaining. Engineers are not conditioned by temperament or training to feel comfortable in the pulling and hauling of the collective bargaining process. They tend to seek what they believe to be the right answer to the problems raised, not recognizing that some are purely political, growing out of the needs of a collective action and that others are simply part of the strategy and tactics, the horse-trading, of the bargaining technique. Engineers, tending to approach such problems along the route of the scientific method, are more often than not, bewildered when that does not work, and tend to find it a very frustrating experience.

In view of this how can we account for the fact that some 13 or 14 different labor organizations currently represent engineering employees and for the fact that unionization is today one of the "hottest" subjects under discussion by engineers. Primarily I believe it is one of the manifestations of the awakening of engineers to the fact that engineering is a profession and that its professional status should be raised and made better known to the public. Dissatisfied with the failure to date of any overall unifying organization, some engineers have turned to unionization as a possible answer. They apparently make the error of believing that the overall organizations in the medical and legal professions are collective bargaining organizations.

Furthermore, the demands which the engineering collective bargaining organizations have made in recent years seem to be based much more on the economic position of the engineer in society than upon dissatisfaction with local conditions. Therefore, we may look upon the question of engineering unions as a national problem rather than a local one. For the moment, at least, engineers as a group seem over-whelmingly concerned with their level of pay. Feeling that the unions and union practices have tended to raise the pay levels of their members, some engineers have turned to unionization as an apparently quick and easy way to get their own pay raised. I believe the engineers who, for whatever reason, chose this approach make a serious mistake and that organization for collective bargaining is definitely not the answer to the engineer's problems. First of all, scientific and engineering accomplishment thrives best in a free and unregimented atmosphere; second, the traditional practices of trade unions, while inevitable, are impracticable in an engineering organization, and third, the engineer by nature and training finds the practices of collective bargaining unsatisfactory and unacceptable.

Courses of Action

Therefore, we need to consider what courses of action we might take in dealing with this problem.

First, the schools and colleges. They must somehow instill in the young engineer the conviction that he is a professional and that he and his profession will progress only in proportion to the exercise of his own abilities and efforts. He must understand that his own inner resources will take him most rapidly and profitably along the road he wants to go. I am not so sure that as a layman I know how this can be accomplished, but if engineering is to become a highly accepted profession, those who practice it must learn the meaning and ethical responsibilities of professionalism.

Furthermore, the schools and colleges may defeat their very purpose when they advise or condone the better men refusing employment with a company solely because its engineers are in a collective bargaining unit. It is only by having

the better engineers meet this challenge and lend their influence in such groups that the question can be satisfactorily resolved. To isolate them may result in a permanent division of engineers into two opposing camps.

Second, the Technical Societies. The technical societies must look beneath the surface of the collective bargaining question in order to understand it and meet it. This will take patience and understanding. The problem can be evaluated and solved only in a calm and tolerant atmosphere. It is a problem already overcharged with emotionalism. The societies do need to be more vigorous in finding the key to some unification or integration in professional affairs. On the other hand, to try to meet the problem of unionization by becoming collective bargaining agencies themselves would be fatal. They would inevitably then find themselves moving in the direction of the typical labor union behavior and practices.

Third, industry. Industry has a serious challenge to understand and practice its part in the professional relationships with its engineers. Under the law, if its engineers elect to bargain collectively it must do so in good faith. On the other hand, it must at the same time make certain that the collective bargaining does not destroy, any more than can possibly be avoided, the maintenance of that freedom of individual accomplishment and of intercommunication that is essential to the attainment of the best professional results.

Finally, the engineer himself. Whether or not engineering advances as a profession or whether collective bargaining or the individual relationship is to be characteristic of the engineer in industry rests almost entirely with the individual engineer himself. The most any of the rest of us can do is to encourage him to take a sincere interest in this important subject, to create an atmosphere conducive to his proper consideration of it and to supply him as completely and objectively as we can with the views, experience, and data we may have on it. Engineering ethics, from the viewpoint of industry, will rise or fall on the decisions of the engineer himself.

The Growth of Graduate Study in Engineering*

By HENRY H. ARMSBY

Chief for Engineering Education, Department of Health, Education & Welfare

This paper is one of three to be presented by a panel formed to explore the future role of graduate study in engineering and to furnish some background material for a comprehensive study of graduate engineering education, somewhat comparable to the study which has been underway for the past two years by the ASEE Committee on Evaluation of Engineering Education. The special function of this paper is to present a few statistics and estimates, gathered from various sources, which outline the growth of graduate engineering study up to the preesnt time, leaving to other members of the panel any attempts to forecast the future.

To a mathematician these statistics will probably leave something to be desired, since the agreement among different sets of statistics is not perfect, for many reasons. Perhaps the chief reason for the differences is the fact that our definitions of "engineer" and "scientist" are not entirely satisfactory. In this respect, the engineers are better off than the scientists, since there is a little greater agreement as to who is an engineer than there is as to who is a scientist. There is also more information available about the engineering profession than there is about natural scientists. Only within the last few years has an attempt been made to gather accurate statistics on these groups.

* Paper presented before the Graduate Studies Division at the Annual Meeting of the American Society for Engineering Education, June 16, 1954.

However, there is no need for great concern over the absolute accuracy of the figures. The lack of agreement between different sources is not sufficiently large to invalidate general comparisons, and the overall picture of the situation with respect to graduate study in engineering is reasonably accurate.

Numbers of Engineers and Scientists

A few general figures may serve to set the stage for more detailed ones. There is general agreement that the total number of engineers at the present time is approximately a half million, which is about 12 times the number of engineers we had in 1900 and about twice the number we had in 1940. Something like 80% of these are college graduates, and the proportion is steadily increasing. Probably the great bulk of replacements and of new additions will come from the engineering colleges. The number of scientists is generally considered to be somewhat less than half the number of engineers. This number has also approximately doubled since 1940.

The National Science Foundation Report

A report prepared in January 1954 by the National Science Foundation for the Science Advisory Committee of the Office of Defense Mobilization shows that the population of the United States increased from 39.8 million in 1870 to 151.4 million in 1950, an increase of 280 per cent. During the same period the number of professional, technical, and

kindred workers increased from 0.4 million to 5.0 million, an increase of 1150%; and those employed in science and technology increased from 12 thousand to 1019 thousand, an increase of 750%. From 1930 to 1953 the population increased 28%, the number of engineers 133%, and the number of scientists 335%. In this report the term "Scientists and Engineers" includes those with baccalaureate or higher degrees, or their equivalent in professional experience, who are employed in the recognized branches of the natural sciences, the engineering sciences, and mathematics.

The same report states that from 1912 to 1951, inclusive, a total of 46,711 doctorates were conferred in science and engineering, of which 47% were in the physical sciences, 42% in the biological sciences, 5% in the earth sciences, and 6% in the engineering sciences.

The American Council on Education Report

All levels of education, secondary, college, and graduate, have grown rapidly since 1900, with the graduate level showing the most rapid growth. A report published by the American Council on Education in 1951 entitled "The Production of Doctorates in the Sciences, 1936 to 1948" contains a large amount of valuable data. In this report the term "science" is used to include the physical sciences, the biological sciences, the earth sciences, and engineering, and a "scientist" is defined as a person having a doctor's degree in one of these fields.

The authors of this study present evidence which suggests that the three levels in education have taken hold in America in waves about thirty years apart. Enrollment in secondary education grew from 4% to 32% of the age stream (14 through 17) during five decades starting with 1870. This agrees almost exactly decade by decade with the growth in higher education enrollment from 4% to 29% of its age stream (18 through 21) for five decades starting with 1900. Relating enrollment to its age stream has the effect of holding the population constant, and shows how much faster the enrollment has grown than has the population in the age group under consideration. Thus the figures quoted above mean that from 1900 to 1950 college enrollment grew 7 times as fast as the number of persons of college age. This is about what happened to high school enrollment 30 years earlier, when it grew 8 times as fast as its age group. There is some evidence that graduate enrollment has started on a similar expansion.

The study shows that between 1890 and 1950 enrollment in secondary education grew to 36 times its original number; in all higher education to 17 times; and in graduate schools to 100 times. Factors for completion of various levels of education are; high school graduation 52 times, bachelor's and first professional degrees 28 times, master's and second professional degrees 58 times, doctor's degrees (all fields) 50 times, doctor's degrees (science) 71 times.

As fractions of the age stream the growth factors are as follows; high school graduation 20 times, bachelor's degrees (excluding veterans) 10 times, doctor's degrees (all fields) 24 times, doctor's degrees (science) 33 times.

The authors of the study state that "the principle is clear that, within limits, social factors are stronger than variations in the actual number of persons in the age stream. Whatever the 1960 college enrollment turns out to be will depend primarily on social factors, the demand for educated persons, and the facilities for obtaining an education. The high school data make it perfectly clear that amazing growth can be achieved over and above population change."

Of the doctorates earned during the period covered in detail by this report (1936–1948) 5% were earned in engineering, 32% in chemistry, 9% in physics, 5% in mathematics, and 4% in the earth sciences. Of those who had earned doc-

TABLE 1

GRADUATE DEGREES IN U. S. COLLEGES,
DISTRIBUTION BY FIELD OF SPECIALIZATION,
1929–30 TO 1952–53

Field of specialization (1)	1929–30 (2)	1939–40 (3)	1949–50 (4)	1950–51 (5)	1951–52 (6)	1952–53 (7)
Engineering						
Number	812	1,460	4,913	5,345	4,620	4,084
Per cent of total	(4.7)	(4.9)	(7.6)	(7.3)	(6.5)	(5.9)
Physical Sciences						
Number			4,682	4,881	4,774	4,425
Per cent of total			(7.2)	(6.7)	(6.7)	(6.4)
Mathematics						
Number			1,134	1,293	1,008	918
Per cent of total			(1.7)	(1.8)	(1.4)	(1.3)
Healing Arts and Med. Science						
Number	104	547	1,683	1,722	1,999	1,982
Per cent of total	(0.6)	(1.8)	(2.6)	(2.4)	(2.8)	(2.9)
Biological Sciences						
Number			2,796	3,135	3,071	2,857
Per cent of total			(4.3)	(4.3)	(4.3)	(4.1)
Agriculture and Forestry						
Number	405	822	1,873	1,947	2,020	1,943
Per cent of total	(2.3)	(2.7)	(2.9)	(2.7)	(2.8)	(2.8)
Social Sciences						
Number			11,932	12,127	8,838	11,047
Per cent of total			(18.4)	(16.8)	(12.4)	(15.9)
Education						
Number	1,486	9,957	21,062	25,326	27,528	28,184
Per cent of total	(8.6)	(33.3)	(32.6)	(35.0)	(38.7)	(40.6)
All Others						
Number	14,452	17,235	14,777	16,694	17,296	13,892
Per cent of total	(83.8)	(57.3)	(22.7)	(23.0)	(24.4)	(20.1)
Total						
Number	17,259	30,021	64,852	72,470	71,154	69,332
Per cent of total	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
Exhibit						
Eng'g, Phys. Sci., and Math.						
Number			10,729	11,519	10,402	9,427
Per cent of total			(16.5)	(15.8)	(14.6)	(13.6)
Ph.D. Degrees, All Fields						
Number	2,216	3,290	6.633	7,338	7,683	8,309
Per cent of total	(12.9)	(10.9)	(10.2)	(10.1)	(10.8)	(12.0)

torates in engineering about 64% were engaged in engineering as such. Corresponding figures for the other fields are; Chemistry 98%, Physics 96%, Mathematics 100%, and Earth Sciences 116%. The last figure means that at least 16% of the earth scientists earned their doctorates in some other field.

Developments since 1950

Most of the statistics quoted thus far show developments up to about the year 1950. It is somewhat unfortunate that many of the statistical studies concerning scientific and professional manpower stop with this year, since for a good many indices this year marked the all time high point, as is evident in the three tables which form a part of this paper.

The data in these tables for the two decennial years 1929–30 and 1939–40 are drawn in part from records of the U. S. Office of Education, and in part from the previously mentioned report of the American Council on Education. Those for 1949–50 and subsequent years are taken from the Office of Education annual studies of earned degrees in U. S. Colleges. The breakdown by fields is less complete for the years 1929–30 and 1939–40 than for 1949–50 and subsequent years, but the figures which are shown for the earlier years are believed to be comparable to those for the later years.

Table 1 shows the numbers of graduate degrees granted in each of eight fields since the year 1949–50, and in four of these fields for the years 1939–40 and 1929–30. In each cell the first figure is the number of degrees granted, and the second figure (in parentheses) is this number converted to a percentage of the total number of graduate degrees conferred during the academic year. It will be noted that engineering degrees constituted a rising percentage of the total until 1949–50, but that this percentage has been dropping ever since. Data for the physical sciences and for mathematics are not available for earlier years, but since 1949–50 both percentages have been dropping. The percentage in social sciences declined from 1949–50 until 1951–52, rose again last year, but has not yet returned to its 1949–50 level. The

TABLE 2

GRADUATE DEGREES IN U. S. COLLEGES,
AS PERCENTAGES OF 1949–50 DEGREES IN EACH FIELD,
1929–30 TO 1952–53

Field of specialization (1)	1929–30 (2)	1939–40 (3)	1949–50 (4)	1950–51 (5)	1951–52 (6)	1952–53 (7)
Engineering	16	30	100	109	94	83
Physical Sciences			100	104	102	94
Mathematics			100	114	89	81
Healing Arts and Med. Science	6	32	100	102	119	118
Biological Sciences			100	112	110	102
Agriculture and Forestry	22	44	100	104	108	104
Social Sciences			100	101	74	92
Education	7	47	100	120	131	134
All Fields	27	46	100	112	110	107
Exhibit						
Eng'g, Phys. Sci., and Math.			100	107	97	88
Ph.D. Degrees, All Fields	33	49	100	111	116	125

TABLE 3

EDUCATIONAL INDICES AS PERCENTAGES OF 1949–50 INDICES, 1929–30 TO 1953–54

Index (1)	1929–30 (2)	1939–40 (3)	1949–50 (4)	1950–51 (5)	1951–52 (6)	1952–53 (7)	1953–54 (8)
Enrollments							
All College	45	61	100	93	86	88	92
Undergrad. Eng'g		56	100	87	79	84	92
Graduate Eng'g		31	100	105	110	115	122
Degrees							
All B.S. and 1st Prof'l	28	43	100	89	76	70	
Male B.S. and 1st Prof'l	22	33	100	85	69	61	
Eng'g B.S.	14	24	100	79	58	46	36*
All Graduate Degrees	27	46	100	112	110	107	
Engineering Graduate Degrees	16	30	100	109	94	83	
Phys. Sci. and Math. Graduate Degrees			100	106	99	92	
All M.S. Degrees	26	46	100	112	109	105	
Engr. M.S. Degrees			100	107	91	79	
All Ph.D. Degrees	33	49	100	111	116	125	
Eng'g Ph.D. Degrees			100	125	127	124	

* Estimated.

percentage of degrees in healing arts and medical science shows a slight increase for the three-year period; those in biological science a slight decrease. Graduate degrees in education have shown an astonishing increase in their percentage of the total, and for 1952–53 constitute more than 40 per cent of the total. This is undoubtedly due to the raising of teacher certification standards in various states and localities, and to the nearly universal requirement of graduate degrees as a qualification for educational administrative positions. Perhaps there is a suggestion here for the engineers.

In Table 2 the figures shown in Table 1 are converted for each of the 8 fields into percentages of the number of advanced degrees granted in that particular field for the year 1949–50. The figures, therefore, represent a measure of the relative rates of change of graduate education in the different fields. They show for instance that in engineering the degrees granted in 1949–50 were about 6 times as many as in 1929–30, while in 1952–53 they are only 83% as numerous as they were in 1949–50, and about 5 times as many as in 1929–30. In education the 1949–50 output was about 14 times that in 1929–30, and the 1952–53 output was nearly twenty times. For the healing arts and medicine, the 1949–50 output represented sixteen times that of 1929–30, while the 1952–53 output was almost twenty times. Engineering, mathematics, and physical sciences have consistently lost ground since their peak year of 1950–51, and the biological sciences to a lesser extent, whereas the healing arts and education have consistently gained ground.

Table 3 contains similar comparisons, using the 1949–50 figure as 100%, for a number of different indices, grouped for ready comparison. Enrollment in-

dices are extended to the year 1953–54, others only through 1952–53. The bachelor's degree in engineering shows the largest percentage drop of any of the indices. However, it is encouraging to remember that this year's graduating class will mark the low point, since engineering freshmen have been increasing in number consistently since the fall of 1950, and for this year are 176% of the 1950 class. They should produce, according to past performance, about 34,000 graduates in 1957, which is 65% of the number produced in 1949–50.

The bright spot for engineers in Table 3 is the fact that the number of Ph.D. degrees conferred in engineering has shown a steady climb since 1949–50, as has the total number of Ph.D.'s conferred. The engineering Ph.D.'s exhibited a slightly greater climb during the first two years of this period, but dropped off a little last year. However, the enrollment for candidates for the Ph.D. in engineering has increased each year since 1949–50, so that the index for this year may perhaps be larger than that for 1952–53.

Effects of Selective Service Policies

The number of graduate degrees in engineering and other fields which will be granted this year and in the future will depend to a considerable degree upon the policies of Selective Service with respect to the deferment of graduate students. The *Engineering Manpower Commission Newsletter* No. 58 (dated May 11, 1954) states that "For the year ending April 30th, Selective Service has interrupted the advanced graduate training of approximately 250 students per month, and has taken another 300 per month (average) from those who received bachelor's degrees and who would normally have entered graduate schools for higher degrees in science and engineering."

The Commission also points out that there has been a steady decline in the number of occupational deferments, averaging 900 per month during the last three months for which figures are available, and says "With draft quotas at 18,000 per month, this means that Selective Service is meeting 8% of the requirement from a group that comprises a critical 1% of the labor force."

Basic Federal Policies

Such a situation, in view of the current shortage of engineers and scientists and the probability that the shortage will continue for a good many years to come, points up the need for a realistic, practical, and democratic National policy which will avoid mandatory controls over the civilian population, but which will enable the nation to achieve the optimum development and use of its most important asset, its human resources.

The basis for such a policy was laid down by President Truman in his "National Manpower Mobilization Policy" in January 1951, and was later amplified by the Office of Defense Mobilization in September 1952 in its Defense Manpower Policy No. 8 entitled "Training and Utilization of Scientific and Professional Manpower."

Both these documents stress emphatically the need of the Nation for scientists and engineers, and both are based on the fundamental principle that each individual should be expected to serve in the capacity in which he can contribute most effectively to the total mobilization program.

The Office of Defense Mobilization's Committee on Specialized Personnel has recently prepared a set of recommendations concerning occupational and student deferment policies. The committee calls attention to the Report of the Committee on Manpower Resources for National Security (the "Appley Committee") which stressed the fact that "in the event of an emergency, our resources of highly trained manpower will probably be the ultimate limiting factor in our capacity for full mobilization."

The committee's report indicates its belief that "present occupational deferment practices are not contributing fully to the object of maximizing the technological strength of the nation" and that "the induction of graduate students in science and engineering has significantly reduced our potential of highly trained scientists and engineers," although the undergraduate student deferment program has been quite satisfactory. The committee recommends a general review and revision of occupational and student deferment policies, which they state should be related to long term needs as well as immediate needs, and should be based at least in part on *prospective use* of professional manpower rather than merely on *present occupation.* The committee recommends a continuation of the present criteria with respect to undergraduate student deferments, but with respect to graduate students, it suggests the following;

"(1) When a student has been deferred by his draft board during his undergraduate years, if he is a candidate for an advanced degree his case should be reviewed immediately upon graduation. If he is among the few who are qualified and accepted for graduate study, consideration should be given to extending his deferment.

"(2) If deferment is granted for entering upon graduate study, it should be continued if the student is making satisfactory progress which, if continued, would result in his obtaining the Master's degree (or equivalent) within two years. At the time of this degree, the case may again be reviewed.

"(3) If deferment is granted beyond the Master's degree (or equivalent), it should be continued if the student is making satisfactory progress which, if continued, would result in his obtaining the Doctor's degree within three years."

The favorable reception accorded by the President to the Appley Committee recommendations for a reorganization of the military reserve, the recommendations of the ODM Committee on Specialized Personnel, and the establishment by the Selective Service System of a few experimental committees to advise local and State boards with respect to the deferment of specialized personnel, give some evidence that a realistic National policy concerning the utilization of scientific and professional manpower is slowly evolving. (Editorial Note: These recommendations have since been adopted in essence by the ODM Manpower Policy Committee.)

Mid-Winter Meeting of Engineering Drawing Division

Time: January 27, 28, 29, 1955.

Place: University of Tennessee, Knoxville, Tennessee.

A three day session of technical programs and inspection trips which will include technical papers and panel discussions by teachers of engineering drawing and men from industry. Inspection trips will include Oak Ridge National Laboratories and Great Smoky Mountain National Park. Detailed programs will be mailed to members of the Engineering Drawing Division.

What Is and What Will Continue to be the Supply of People Qualified to Do Graduate Work in Engineering?*

By C. O. HARRIS

Head, Applied Mechanics, Michigan State College

Graduates of Recent Years

The supply of people qualified to do graduate work in engineering is practically limited to those who have graduated in an engineering curriculum and have shown promise of success in continuing their studies. An idea of numbers may be gained from Table 1, which presents the totals of engineering graduates of recent years, from institutions which have at least one curriculum accredited by ECPD.

TABLE 1

ENGINEERING GRADUATES (1)[1]

School year	No. of first degrees
1946–47	18,592
1947–48	27,460
1948–49	41,793
1949–50	48,160
1950–51	37,904
1951–52	27,155
1952–53	21,642
Sum	222,706

Not all of these people are qualified to do graduate work in engineering. Some factor, possibly 25 per cent, must be applied to figures of this type to obtain the number who would be likely to do well in graduate school.

Future Graduates

The future supply of people who are qualified to do graduate work will depend upon the numbers of engineering graduates in the future. Table 2 presents estimates of the numbers projected through 1970.

TABLE 2

COLLEGE GRADUATES IN THE UNITED STATES, PROJECTED TO 1970

School year	First degrees	First degrees, engineering	% engr. deg. of total	8% of total
1939–40	186,500*	11,400*	6.1	—
1949–50	434,000*	48,200*	11.1	—
1950–51	384,000*	37,900*	9.9	—
1951–52	332,000*	27,200*	8.2	—
1952–53	305,000*	21,600*	7.1	—
1959–60	326,000**	—	—	26,100
1964–65	454,000**	—	—	36,300
1969–70	591,000**	—	—	47,400

*Actual.
** Estimates.

The estimates of numbers of first degrees are taken from a paper by Oxtoby, Mugge and Wolfle (2). An interesting figure in the background of these estimates is that the proportion of high school graduates who enter college appears to have stabilized at about 35 per cent. Wolfle (3) states that the percentage of graduates majoring in engineering remained fairly constant from 1900 to

* Presented at the Annual Meeting of ASEE, Graduate Studies Division, University of Illinois, June 16, 1954.

[1] Numbers in parenthesis refer to bibliographical items at the end of the paper.

1950. The three figures in the last column of Table 2 are 8 per cent of the total numbers of first degrees, and represent one estimate of the numbers of engineering graduates. The estimates in Table 2 are based on long-time trends and are subject to deviation, due to such factors as depressions, wars, GI bills, etc. However, it is interesting to note that it may be some time before the numbers of engineering graduates are substantially above those of recent years.

Again, not all of these graduates will be qualified to do graduate work. However, the numbers do indicate the size of the pool from which the engineering graduate students of the future must be drawn.

On whether the percentage of engineering graduates qualified to do graduate work is likely to increase, Dr. Dael Wolfle, Director of the Commission of Human Resources and Advanced Training, says, "A little general information indicates that the caliber of college students has not changed significantly for the past thirty years. . . . One of our own studies adds the additional fact that the relative standing among college graduates of those who specialize in any particular field has not changed since 1920 at The Ohio State University—the one school where we were able to make detailed analyses of this kind."

Effect of Military Service

Many promising students are likely to forego graduate work because of their obligations to military service. Mr. Armsby has discussed Selective Service policies and practices in his paper. In addition to those students who have been, or are likely to be drafted, there are many engineering students who are enrolled in advanced work in the Reserve Officer Training Corps, and who face two years of military service when they graduate. Table 3 shows the percentage of juniors and seniors in engineering who are enrolled in ROTC at Michigan State College, as an example of conditions at one Land Grant college.

TABLE 3

Spring term	% juniors in ROTC	% seniors in ROTC
1952	43	23
1953	30	36
1954	32	35

TABLE 4

UNDERGRADUATE STUDENT CHARGES AT AMERICAN UNIVERSITIES (4)

Type of univ. and number reported on	Av. 1940	Av. 1950	% increase
Private (24)	$330	$504	52.6
Public, resident (25)	103	158	54.0
Public, non-resident (25)	193	349	81.2

Industrial Opportunities for the Graduate

The great demand for engineering graduates has led to such attractive financial offers to graduates that many excellent students who could benefit from graduate work choose to enter industry immediately upon graduation. This fact is well known to all of us, and must be considered as a factor in estimating the future supply of graduate students.

Increase in Student Charges

The increase in the cost of maintaining a student in college is likely to cause many capable students to decide not to attend graduate school. Student charges have increased substantially at American universities, as is shown in Table 4. Tuition for graduate students may not be an important factor, since tuition is waived for so many graduate students, but the payment of high tuition rates and high prices for board and room during four years of undergraduate school may have placed such a financial burden on a young man and his family that he feels a need to start earning as soon as possible.

Those Who Don't Go to College

There is an abundance of evidence to show that there are many capable young men who do not attend college, often for economic reasons. The President's Commission on Higher Education (5) cites a University of Minnesota study in the early 1940's to the effect that for every student in the top 10 per cent of his high school class who goes to college, there is one in the top ten per cent who does not go; for every student in the top 30 per cent who goes to college, there are two who do not go. Also, Millett (4) says that only 60 per cent of the top 2 per cent, in intellectual promise, of the 18 year olds in this country enter college; only 44 per cent of the top 10 per cent enter; and only 40 per cent of the top 25 per cent enter.

Wolfle (3) tells of a study of all the Minnesota high school graduates of 1950, by Ralph Berdie, who found that about half of those who were in the top 10 per cent, but who were not going to college the following year, said that they would go to college if they had the money.

The President's Commission has recommended a broad program of undergraduate scholarships to enable more of the most highly qualified young people of this country to go to college. Any development of this type is certain to add to the number of people who are qualified for graduate study in engineering.

Distribution of Ability

Some information is available on the distribution of ability among graduates in engineering. The figures in Table 5 are test scores converted to the Army General Classification Test Scale. On the AGCT scale, the average person in the total population earns a score of 100. Also, it might be taken as an approximate statement that a score of 110 indicates the minimum level of ability for graduation from college. The average person earning a bachelor's degree scores about 126.

TABLE 5

PERCENTILE SCORES OF ENGINEERING GRADUATES (ON AGCT SCALE) (6)

	Percentile				
	10	25	50	75	90
Graduates	115	122	129	137	145
Graduate Students	118	123	131	139	145
Ph.D.'s	121	131	138	149	153

The meaning of the term *percentile* may be explained by the statement that a person in the 25th percentile scored higher that 24 per cent of those who took the test, but lower than 75 per cent.

Table 5 indicates that there is not a great deal of difference, on the AGCT scale, between engineering graduates and graduate students in engineering. Also, a substantial number of graduate students in engineering score lower that the 50th percentile of engineering graduates. If these people can be successful in graduate work in engineering, it would certainly be of interest to inquire how they were able to rise above their seeming intellectual level and do well enough to impress an engineering faculty as being qualified for graduate work. If there are special motivation factors present in these cases, it would be desirable to discover them so that they might be applied more broadly. It would also be of interest to see how successful such people are in graduate study, and whether they do manage to complete a rigorous program of work.

Whatever the conclusion on this point of distribution of ability, it appears to be a proper subject of inquiry for those interested in the supply of people qualified to do graduate work in engineering.

Summary

It appears that, by 1970, the number of engineering graduates per year will approach the number of the peak year of 1949–50, up to an estimate of 47,000,

and that the percentage who are qualified for graduate work will remain about the same as at present. However, such factors as military service, high industrial salaries and increases in student charges may cause many excellent students to forego graduate work.

There seems to be some hope for increasing the number of qualified graduate students in a program of undergraduate scholarships and in a study of distributions of ability.

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College Notes

Polytechnic Institute of Brooklyn, the country's second largest engineering school, will emphasize interpretation of its centennial theme, "Science, Engineering, Research for Human Well-Being," during its centennial year, according to the plans disclosed by President Harry S. Rogers. Chartered in 1854 as the Brookyln Collegiate and Polytechnic Institute, the school admitted its first class of 267 students in September 1855. Today over 6500 students attend its undergraduate and graduate schools in day and evening sessions.

Prof. Frank Kerekes, well-known structural engineer and teacher, has been appointed dean of academics at the **Michigan College of Mining and Technology** by the Board of Control, it was announced by Dr. Grover C. Dillman, president of the college and secretary of the Board.

Kerekes has been on the faculty of Iowa State College since 1920, where he served as professor of civil engineering and assistant dean of engineering.

Formation of an Engineering Council of 24 men to advise and assist in the development of the **University of Pittsburgh** schools of engineering and mines was announced by Chancellor R. H. Fitzgerald and Dean G. R. Fitterer, dean of the schools.

Factors Affecting the Supply of Graduate Students in Engineering*

By D. F. PETERSON, JR.

Professor and Head of Civil Engineering, Colorado A. & M. College

Introduction

My topic for discussion is the question, "What measures are likely to be successful in increasing the supply of graduate students in engineering?" Preliminary thinking about this topic led to the early realization that a comprehensive study arriving at the relative importance of the various factors and predicting the possible quantitative results which might be achieved would be beyond the scope of my individual effort. This paper, therefore, will be limited to simply summarizing some of the more likely factors involved and commenting on some of the more obvious aspects of these. Our chairman has already sounded a call for a comprehensive evaluation of graduate education in engineering, and if this study is made, certainly the topic which has been assigned to me for discussion here today will be developed fully and quantitative answers arrived at.

Separating graduate-student manpower problems from the problems of undergraduate manpower is impossible. Accordingly much of this discussion may, on the surface, appear to be concerned with under-graduate problems. I think, however, the relation to graduate problems will be evident.

Presumably any program which leads to an increase in either the quality or number of high school graduates entering engineering colleges ought also eventually to increase the supply of graduate students in engineering.

Although current studies indicate a large and continuing deficiency of engineers educated at the bachelor's level, I think that economic returns to the members of the profession and benefits to society as a whole might be greater if we concentrate on improving quality more than increasing quantity. A normal and healthy increase in bachelor-engineers, consistent with increasing population and industry, is certainly desirable; but I doubt the wisdom of making every possible effort to "get all the engineering graduates that we possibly can."

The problem we face has been stated many times. Each member of our rapidly multiplying population demands more and better material goods in the face of decreasing natural resources and more complex social, economic and political problems to solve. At the same time we are faced with the prospect of inordinate technological expenditure of men and resources for war machinery to insure national survival. These demands can probably never be fully met. The only hope of meeting the minimum is to substitute more machine power for manpower. This will require increasing the supply and efficiency of brain power. We must increase the number of young people capable of working with their brains and we must utilize these much more effectively than in the past.

In our search for an increased number of graduate students in engineering we

* Paper presented before the Graduate Studies Division at the Annual Meeting of American Society for Engineering Education, June 16, 1954.

must not overlook that the sciences and other intellectual fields also will be under great pressure for more brain power. Any practical answer to our problem must consider these requirements also. *Our efforts in evaluating graduate education in engineering, especially as they relate to manpower problems, ought to be correlated with a general study of these needs for all of the sciences.*

Factors Influencing Graduate Engineering Manpower Supply

Factors which might influence young people to follow graduate study in engineering appear to fall into two broad categories. The first of these appears to consist of factors which are clearly economic in nature. The second is not so clearly strictly economic but involves psychological considerations as well.

Economic Factors

Prospect of increased individual financial return.—The prospect of increased individual financial return is probably the most potent motive that could be introduced to stimulate graduate study. The greater this prospect, the greater would be the expected increase in graduate-study interest. Presently little difference seems to exist in the financial returns to persons with advanced degrees in engineering over those holding bachelor's degrees.

We have assumed that graduate study in engineering is valuable to society. If this is true, why have not supply and demand operated to create a comparable reimbursement? Perhaps the answers may be found partly in the facts (1) that most advanced-degree engineers have been employed in education, which is somewhat protected from the laissez-faire operation of economic law; and (2) that employment by industry of engineers with advanced training is generally relatively recent and that time will be required before persons holding these degrees mature, if they will, into higher paid brackets.

Control of engineering wage scales based on degree held or years of advanced study might be possible. If not by legislation, this could be accomplished by unionization. Pay increases in the education profession often result automatically as the result of no other qualification than possession of an advanced degree. This has stimulated graduate activity in education. Many people feel however that this artificially stimulated endeavor has detracted from the quality of advanced work in the educational field. I certainly do not favor any such drastic measures in engineering.

Increased financial return to better-educated engineers can probably come about only because of proven increased economic worth to industry or to the public of the individual concerned. This may be difficult, because intellectual achievement is sometimes not marketable to society at its true worth. *Without doubt, however, resulting individual financial return to advanced-degree engineers needs to be increased if graduate work in engineering is to be stimulated.*

Meeting the high cost of graduate work to institutions of higher learning.—One important factor affecting the attractiveness of graduate work is doubtless the professional reputation, personal enthusiasm and inspirational quality of graduate teachers and leaders; another is the importance and support available for graduate research programs. Worthwhile graduate work is expensive and universities are faced with a decreasing unit purchasing power in the face of demands for increased mass education at the college level. Many schools have met this problem, to some degree at least, by venturing into contract research. This source of income helps pay professor's salaries, and furnishes assistantships and graduate research projects. Contract research is not without its difficulties, however, as those who are involved are well aware. These programs make additional demands on the already short supply of manpower capable of high-grade graduate leader-

ship. Many research sponsors do not recognize the true costs to the institutions of these activities—staff time, facilities, apparatus, and administrative costs are often not allowed. These costs can be met only by decreased institutional services elsewhere. *More liberal support of sponsored research is needed.*

Industrial contributions to research in colleges has been stimulated in recent years by operation of the excess profit tax and by high corporate income taxes. Under these, each dollar of research effort costs the owners only about 18¢. With the discontinuance of the excess profit tax and the decrease in the corporate income tax, the share per dollar of the cost now becomes about 54¢, thus effectively tripling the cost to the corporation of such research. Perhaps this may not decrease corporate sponsored research as much as the figures indicate, because the corporations will have a larger supply of cash at their disposal. We hope they may recognize the importance of investing continuing large sums in research on our campuses. Perhaps some preferential tax concessions on funds spent this way ought to be considered as a means of stimulating this source of income to the colleges and universities. This public cost could be justified on the basis of the value to the nation of the continuing research effort in colleges.

Contract research grants are helpful, but they can only partly answer the problem. *Graduate schools need more adequate general financing.* This is especially true of the smaller institutions, who find it increasingly difficult to employ and to hold the interest of really well-qualified professors necessary for graduate work. This is true both in engineering and in the supporting sciences. For the publicly-financed institutions some means must be found to make legislatures recognize the importance of investing public funds in graduate activity. Privately-financed institutions have an even more difficult problem of finding adequate financial support.

Increasing the number and value of fellowships and assistantships.—A very important factor in the supply of graduate students must be the availability and monetary value of fellowships and assistantships. Presently research assistantships are relatively easy to obtain. Fellowships are more difficult. Graduate work in engineering would be stimulated if more fellowships were available. The number of fellowships in engineering under the National Science Foundation is helpful but inadequate.

The subsidy to education under the G.I. bill operates essentially as a huge fellowship program. This subsidy has not only directly supported graduate students but has increased the number of graduate students by simply increasing the number of bachelor's degrees. If and when G.I. benefits are discontinued, something will probably have to take their place. *Perhaps the idea of mass subsidy may be replaced by increased public sponsorship of young people of superior ability by the National Science Foundation, and by comparable agencies at the level of state, city and school district.*

Special consideration in regard to military service for talented graduates.—Deferment from their military obligations of talented graduates who wish to pursue further study would be helpful. If our object is to be realized, public policy on this point should probably be liberalized. The problems involved are not simple and extend from current logistic considerations all the way back to our basic concepts of democracy. This aspect of our problem has already had a lot of consideration. It will have to come in for considerably more if we pursue our proposed evaluation of graduate work in engineering.

Availability of graduate courses to young engineers in service.—Doubtless many young engineers who are employed full-time will elect to do graduate work on a part-time basis if such programs are readily available to them. These programs frequently utilize night classes. I have had very little experience with part-

time programs and I will leave discussion of this point to someone else. Co-operation of industry and public agencies is vital to stimulation of programs of this nature. A conference on co-operative education at the graduate level was held at Troy in connection with the 1949 annual meeting of ASEE and the various papers presented have been published as a bulletin of the Graduate Division.

Competition with the sciences for graduate personnel.—All of the sciences are faced with impending manpower shortages. We can accordingly expect that competition for scholars of extraordinary ability will continue. Supply and demand will probably operate fairly well to establish equitable distribution among the various sciences and engineering, and I would not advocate an artificial program to divert manpower from one or another of these professions. *What is needed is a concerted effort on the part of all to encourage talented youngsters to enter science and engineering rather than commercial or other less intellectual fields.*

Psychological Factors

Fortunately not all of the factors which influence young persons to enter a graduate career in engineering are economic. For lack of a better term, I have lumped these factors together and called them psychological factors. There are a great many of these of relatively minor importance, but which, nevertheless, ought to be exploited if we seriously undertake an effort to increase graduate activity. These factors include such items as (1) the opportunity to do creative work of lasting value, (2) the possibility of service to the public, (3) natural scientific curiosity; etc. Stimuli of this kind operate naturally in our favor. Probably ways can be developed to make them more effective.

Another point which would appear to have some influence on a person choosing a profession is the quality of professional status enjoyed by members of that profession. Everyone seems to agree that there is room for improvement in this regard in engineering. A great deal of effort is presently being made by leaders of the engineering profession in an attempt to improve this status. The success they achieve will probably be reflected in some measure in the success of our recruiting efforts.

Engineers, being practical people generally, are apt to mistrust or fail to appreciate persons who have specialized in highly technical subjects at the expense of field experience. This tendency decreases with time as more rigorous technical efforts become increasingly necessary. Perhaps, better general understanding of the place and value of the engineer with advanced education might eventually add to the attractiveness of this kind of career.

There have been some expressions that graduate school administrators do not fully appreciate the desirable features of advanced work in engineering. Most administrators of graduate work are apt to be recruited from the so-called "pure" sciences. I suppose most of the misunderstanding centers around the classical concept that the purpose of graduate work is to conduct research of fundamental nature. *Development of the most useful graduate curricula in engineering ought to improve the attractiveness of these programs. They should be free to develop without being fettered by traditions or by preconceived ideas based on what may be desirable for programs having different objectives.*

I have briefly mentioned a few "psychological" factors. I have little notion of their relative importance. Some of them may prove to be trivial. I have in mind, however, two factors which seem to me to be of primary importance in producing graduate students. These are (1) improvement in pre-college preparation for engineering and the sciences and (2) more inspiring scientific leadership especially in the secondary schools, but also in the undergraduate colleges. I shall discuss these together because it is difficult to separate them.

Improved secondary education in preparation for science and engineering.—Secondary education has suffered criticism because of a tendency toward superficial treatment of science and pre-science work and its neglect of the talented student. I do not wish to enter into a discussion of the justice of this criticism but merely to place the problem before you.

There is certainly evidence that many objectives of our secondary education program are not conducive to the intensive scholarship habits which young adolescents ought to develop if they are to become effective scientists or engineers. There seems to be good evidence also that preparation in the sciences and mathematics is too often omitted altogether or is of inferior quality when it is included. Habits and interests are pretty well moulded in young people by the time they reach 18 or 19 years of age. If the charges laid at secondary education are true, we are not only wasting valuable, formative years; but losing capable people simply because they have developed other interests without ever having a chance to become acquainted with science or engineering. The apathy of young people toward science and mathematics courses in high school probably could be overcome by better and more inspiring leadership in these fields and by reduction of conflicting interests.

The entire problem of secondary education as it relates to preparation for an engineering or scientific career needs a great deal of thought and study. Mass education must be recognized as a powerful force in realizing the American Dream, yet it apparently has the serious and growing deficiency of neglecting the basic education of our potential intellectual leaders. The problems of overcoming these deficiencies and still maintaining the desirable objectives of mass education are not simple. These conflicting objectives and points-of-view have resulted in verbal brickbats being exchanged between scientists and educators recently. *It is time that scientists and engineers sat down with conscientious leaders of secondary education and did something about (1) determining just how serious these alleged shortcomings are and (2) finding some way to improve the situation with as little sacrifice to all desirable objectives as possible. This responsibility falls upon engineers and scientists as much as on high school leaders and teachers. Our assessment of graduate work needs to include this task.*

Intellectual leadership in the college and university.—There is no substitute for the talented, enthusiastic and inspiring teacher and scientist-engineer who stirs the spark of curiosity, skepticism and imagination in his undergraduate students. You all have met these fellows. The only trouble is that we don't meet them often enough. Perhaps some thought ought to be given to where these fellows come from and how we can keep them in contact with our undergraduate student bodies.

Summary

In trying to make an outline of what factors might be exploited to increase the supply of graduate students in engineering I have considered several which stem principally from economic considerations. Other factors, though in part tied to economy, involve principally other motives and for lack of a better term I have taken the risk of calling them "psychological." Without detailed surveys, any statement about the relative importance of these various factors would be speculation. All that seems possible at the present time is to present them for further discussion and possible future evaluation.

In considering these various factors I could not help but be impressed by the fact that generally the factors which might increase graduate enrollment are also those which would contribute to building strong and effective graduate schools.

The Future Role of Graduate Study in Engineering*

What measures are likely to be successful in increasing the supply of qualified graduate students?

By ERNST WEBER

Polytechnic Institute of Brooklyn

The tremendous rate of new developments in all areas of engineering, but particularly in the new fields close to applied science, namely electronics, solid state, nucleonics, shock waves, supersonics, has placed much greater stress upon graduate study in engineering than we have ever known before. It is generally realized that the conventional four year program can be modified in content to lead to professionally effective young engineers, but that the ability to contribute constructively to the progress of the art can not be sufficiently reinforced within that short period. The requirement of advanced basic mathematical and physical disciplines as a background for the study of these newer phases of engineering has by necessity led to graduate programs, at least in the progressive engineering schools, which are fundamental in character and demand high qualifications of analytical ability and real understanding of the generic principles. This we must keep in mind when we discuss the means to increase the supply of graduate students to eventually satisfy the increased need for broad gauge advanced engineers.

No doubt the differential in salary paid for bachelor's and master's candidates by industry has already increased the number of applicants in graduate schools over what it would be without this salary differential. However, this does not by any means guarantee the most desirable caliber of applicants and, indeed, if we examine the situation objectively, we shall find that this experience holds: the ablest students get the best offers in industry and many of them accept; the still good, but not exceptional, students are apt to stay almost in inverse ratio to their ability. It is hard to refuse to train all of them; after all, we have an obligation to use our facilities in the best way we can.

The emphasis of this discussion is, however, on measures which are designed to attract the most qualified students to continue their studies for advanced degree. This has become a rather serious problem because of the general shortage of engineering graduates.

Perhaps we can divide the problem at once into two phases, concerned with the two basic aspects of required cooperation: the senior class man about to graduate, and the junior engineer on the job. In the first case we must exert sufficient persuasion to *keep* the student from *rushing away* from us; in the second case we must persuade industry or government to cooperate with us to *make* the student *come back* to us for graduate work.

Persuasion of the Senior

How shall we impress the best seniors that they can gain professionally by con-

* Presented at the Annual Meeting of ASEE, Graduate Studies Division, University of Illinois, June 16, 1954.

tinuing studies towards advanced degrees and that, in fact, they have an obligation to the nation to cultivate their abilities to the utmost so as to repay in part for the national effort which gave them education? Certainly not by boring them in the upper years while we spend our efforts to train the average! Certainly not by letting our graduate work just be "more of the same thing"! Certainly not by exacting full tuition when industry is offering them the highest salaries!

To be likely successful in this persuasion we must show appreciation of ability in undergraduate years by individualized programs for the outstanding students. True, the ideal is not feasible, the genuine teacher-student relation in the antique sense is too expensive for most institutions, and probably not even justifiable on social grounds. But we can place the excellent students into honors' programs, let them taste some truly graduate work to challenge their ego to the pride of achievement. We can create an atmosphere contagious with the desire to learn more, because we, the teachers, are studying, probing into new fields, keeping in touch with industrial developments which are not yet ready for undergraduate teaching.

Obviously this means a challenge to the undergraduate faculty. It requires probably the existence of a research program of sufficient scope and magnitude, and the existence of a strong graduate program in which the undergraduate faculty to some part at least participates.

But it might also mean a generous fellowship program in order to supply the extra tone of persuasion, rather important in competition for the young graduate. This again might not be feasible within the finances of many institutions so that outside help becomes important. Here is the chance for a most constructive contribution by government agencies, particularly the National Science Foundation! To be sure, slight beginnings have been made in this direction, but by far not of sufficient magnitude to have significant influence upon the plans of graduating classes.

Now, some will argue that all of this discussion pertains to the large professional school and does not take care of the many smaller engineering colleges. Yet, the attitude of the undergraduate faculty in the smaller colleges should not differ in principle from that in the larger colleges, the only difference being that the research program or the graduate school might be quite distant. It is a fact that many outstanding engineers come from small colleges and a definite service to the nation can be rendered by persuading the ablest seniors to continue study in one of the leading graduate schools.

Evening Programs

Desirable as it might be to take the best seniors into graduate schools, we must rationally accept the fact that the majority of them will take positions in industry, excluding for this discussion the various reserve officer training programs. There are two distinct ways in which qualified students can return to graduate study: one is on a part-time basis in evening programs; the other is by enlightened industrial cooperation through partial or full-time graduate fellowships and scholarships. In either case, this type of graduate education can be most successful if undertaken with full realization of the mutual benefits to be derived.

Though individual graduate courses in engineering had been given in the evening at some institutions perhaps since after the first world war, full evening programs for the Master's degrees in the Engineering fields were first offered by Polytechnic Institute of Brooklyn in 1928. During the first ten years of this pioneering effort, much controversy existed as to the relative merits of full-time day and part-time evening study with the usual traditional views burdened by the inertia of faculty councils who apparently abhorred work for credit in the evening. The tremendous success of the program in terms of enrollment, support by industry, and endorsement by other urban institutions has left no doubt that this might

be the most significant contribution to increase the number of qualified graduate students in engineering.

In a special Conference on Cooperative Education at the Graduate Level,[1] arranged by the Division of Graduate Studies of ASEE in Troy, June 22, 1949, the late Dean H. P. Hammond contributed a discussion emphasizing the importance of part-time evening graduate study and referred to a survey of such opportunities for young engineers, made during 1948–1949 by the Engineers' Council for Professional Development (ECPD). This survey[2] showed that of the fifty communities in the United States in which there are sufficient numbers of young engineers to justify the offering of post-graduate courses, and in spite of the proximity of well qualified institutions, only about a dozen realize this opportunity of service. With this report, the Professional Training Committee of ECPD also published a separate pamphlet "The First Five Years of Profesional Development" and suggested in it a six-point program of post-graduate activity which could and should be stimulated by cooperative effort of the employers, the college, and the engineering societies.

As a tangible step in implementation, a cooperative effort was launched by the Training Committee of ECPD in the Cincinnati area. In response to a folder distributed by a local Industry Committee and describing evening graduate courses made available in September 1953 at the University of Cincinnati, a total of 285 qualified graduate students enrolled in nine selected courses![3]

It appears, therefore, that the establishment of strong evening graduate programs has not been as fully exploited as the existing favorable situations might seem to indicate. Partnership with industry as promoted by ECPD should be most helpful in establishing part-time graduate centers and in securing well qualified graduate students, thus serving the nation with the needed advanced professional training.

Obviously, the stress in any such effort must be on strong graduate programs with fundamental courses and with a well selected faculty whose members have earned reputation in their field through contributions to technical programs of professional society meetings or through technical publications or books. It would be a grave mistake to suddenly invite by gentle pressure a faculty only conversant with undergraduate teaching to step out into evening graduate programs. The evening student, having gained his experience in design and test or measurements assignments, is generally more searching with his questions and less ready to accept pretended authority than the day student who steps from his senior year into graduate study!

National Fellowship Program

The cooperation between the engineering school and industry could and should extend to the promotion of full-time graduate study in the exceptional cases where the value of the student to the company warrants the privilege of a fellowship or of limiting leave of absence for the completion of graduate studies. The whole spectrum of possible modes of cooperation at the graduate level has been extensively discussed in the Conference on Cooperative Education at the Graduate Level to which reference has been made previously.

Surely, if industry values formalized advanced training programs, we should expect genuine understanding of the importance of graduate study in engineering. It should be fully realized that in spite of the unquestioned value of com-

[1] See pamphlet "Papers and Discussions, Coperative Education at the Graduate Level," available through Secretary A. E. Bronwell, or through E. Weber at Polytechnic Institute of Brooklyn.

[2] See the 18th Annual Report of ECPD for the year ending September 30, 1950.

[3] See the 21st Annual Report of ECPD for the year ending September 30, 1953, pp. 13–14.

pany course programs, the place for degree programs is in the University and not in industrial establishments; that more can be gained in the long run by generous support of graduate work in Universities than by competitive effort within industry which by economic necessity must have a non-negligible bias in course objectives.

Unfortunately, the fellowship program sponsored by all industrial organizations is very small, indeed, even though it might look large in each individual organization. To be really effective, a fellowship program of much greater proportions would be needed whereby the students, usually married by this time and possibly with family, could take up full-time graduate study with a tolerable loss of income.

Here again is a challenge to government agencies to supply support on a national basis much beyond the limited funds which the National Science Foundation could make available so far. The industrial strength of this nation turned the tide of the second World War. This industrial strength rests upon scientific engineering to a larger extent than might readily be conceded by the production statisticians. To keep the basic contributions of engineering talent at the highest possible levels we must succeed to train the maximum number of our ablest students to their maximum level of attainment!

In the News

The creation of the General Committee on Nuclear Engineering and Science was announced. The new body, organized under the sponsorship of **Engineers Joint Council**, has been established to "meet the pressing problems of nuclear engineering and the related sciences," with emphasis on the "industrial usefulness" of atomic power.

The Council is constituted of eight leading engineering societies with a total membership of 170,000. The American Chemical Society, which has joined the engineers in the nuclear unit, has 70,000 members. Dr. John R. Dunning, Dean of Engineering at Columbia University, has been elected Chairman of the General Committee. Dr. Donald L. Katz, of the University of Michigan, is Secretary and Program Chairman. The General Committee on Nuclear Engineering and Science stated that it had invited the participation, as members, of organizations of physicists and others concerned with nuclear development.

The General Committee plans a Nuclear Congress to be held July 11–16, 1955 with an expected attendance of 1500. The holding of this Congress, however, is conditioned on the action of the United Nations on the proposal of Secretary of State Dulles for an international conference on the creation of a world bank of fissionable material for peaceful productivity.

"It is the earnest desire of the General Committee on Nuclear Engineering and Science to cooperate fully with such a program," said the new Committee's announcement. "If the United Nations designates a city in North America for a conference in 1955, we shall forego our own Nuclear Congress for that year and we shall be willing to accept the responsibilities for the civilian aspects of the meeting. If the UN conference is held abroad, our Nuclear Congress will be held in a city in the United States to be designated later."

Thermodynamics for Engineers*

By ALI BULENT CAMBEL

Associate Professor of Mechanical Engineering, Gas Dynamics Laboratory, Northwestern University

Probably the main objection to the present day presentation of thermodynamics is that it is antiquated. The thermodynamics that we teach is based on arguments set forth by brilliant men like Carnot, Clausius, Rumford, and Kelvin many years ago. This thermodynamics though "necessary" is no longer "sufficient." Today technology is such that the assumptions of the isolated system, the externally and the internally reversible process are restrictions which are too drastic and oversimplify the problems at hand. The thermodynamics that is needed now is much more general and in it rate processes are of great importance.

It seems to me that as teachers we commit a very serious error. Whenever we realize that what we do is no longer adequate we add a new chapter or a new course to explain what we think should be taught to the student. The result is that we have numerous courses some of which contradict one another and our teaching becomes a process of successive corrections of misconceptions which we impart our students. The standard defense for this type of an approach is that no student ever learns a subject well, unless he takes a more advanced one in that field to force him to understand the prerequisite. Frankly, I cannot believe that our students are that mediocre. I think that we should teach good, up to date thermodynamics once and for all and stop teaching material which we know is no longer absolutely correct or at best is trivial.

Teach Interwoven Discipline

I am also of the opinion that thermodynamics should be taught not as a compartmentalized course but as an overall, widely embracing discipline. We should definitely combine the courses of fluid mechanics, heat power laboratory, heat engines, heat transfer, thermochemistry and thermodynamics into one subject and teach this interwoven discipline as the student will encounter in industry. Just as a preliminary proposal I should like to toss out the topical sequence: 1) Hydrostatics and the concept of pressure; 2) the zeroth law and the concept of temperature; 3) heat transfer by radiation; 4) heat transfer by conduction; 5) heat transfer by convection; 6) thermodynamic properties and phase changes; 7) equations of state; 8) kinetic theory and the theory of mixtures; 9) fluid dynamics; 10) the first law of thermodynamics, first law analysis; 11) the second law of thermodynamics, second law analysis; 12) thermodynamic functions and thermodynamic equilibrium; 13) the third law of thermodynamics and third law analysis; 14) thermochemistry, thermoelectricity and the thermodynamics of irreversible processes.

Among other things this outline (probably consisting of a five semester sequence) strives to accomplish the following:

1) Vapors and gases and liquids are treated so that the student is not led to believe that these are different media, but it is emphasized that the same medium may behave as a gas,

* Reprinted from *Heat Power News & Views*, Vol IX, No. 39, May, 1954.

as a vapor or as a liquid depending on the conditions imposed upon it.

2) Fundamental theory and applications are treated concurrently. Thus for example all cycles would be discussed according to first law considerations while the first law is being studied. Then while studying the second law the principle cycles would again be considered one by one, but this time the restrictions imposed by this law would be taken up. Finally when studying the third law further restrictions would be considered. In this manner the student would thoroughly understand how the laws are used and why certain cycles are not possible. If my experience is any indication it seems to me that few students really understand how the fundamental laws dictate a certain cycle arrangement.

3) The heat power laboratory would run concurrently with the lectures and the student would perform experiments on subjects being discussed in class. This would obviously create trouble because of the undesirability of duplicating equipment. However, this can be overcome easily if we are tolerant and realize that every student does not need to perform a test on every device. Why not have different students test different engines. From the viewpoint of the fundamental laws it does not make much difference whether an internal combustion engine is of the compression ignition type or of the spark ignition type. Thus if we want to educate our students to thoroughly comprehend the fundamentals, one engine is as good as another. If however, we want to train our students to have dexterity in manipulating the controls of some gadget we should not pretend that we are graduating engineers but should admit that we are preparing technicians.

Conclusion

Finally, I would tie in the design sequence in its latter stages with thermodynamics in its latter stages. In the design of a heat engine there are many things which are perfectly possible thermodynamically but are not advisable because of limitations of machine design and metallurgy. Students should know these limitations and should comprehend engineering as it really is.

This suggestion that thermodynamics should be taught with all of its allied fields will be disputed by some who will say "Engineering today is too complicated and hence no man can be expected to understand it all." I disagree in part. It seems to me that engineering today is complicated and accordingly we cannot afford to be mere specialists.

The following four papers were presented in January, 1954 during the annual meeting of the American Association of Physics Teachers in the course of a symposium, "The Responsibility of the Physics Teacher in Engineering Education," under the chairmanship of Joseph H. Keenan, chairman of the AAPT Committee on Engineering Education. These four manuscripts are also being published by the American Journal of Physics.—Editor.

The Responsibility of the Physics Teacher in Engineering Education

By N. H. FRANK

Massachusetts Institute of Technology, Cambridge, Massachusetts

In approaching the subject of the responsibility of the physics teacher in engineering education, and the questions to be answered in this panel discussion, I feel it is necessary first to establish a proper frame of reference with regard to the division of responsibility between the physics teacher and the engineer. One must first ascertain just what are the broad objectives of a physics course in an engineering curriculum and how much time can be allotted for the attainment of these objectives. When these decisions have been made—and they should properly be made by engineering faculties—then, and only then, can one hope to obtain clean, definitive answers to the questions before us.

Without entering into all the ramifications pertinent to such considerations, it will be sufficient for the purpose at hand to determine to what extent, if any, it is expected that physics courses for engineers should form the beginning of a sequence of professional subjects. In other words, just how much *applied* physics belongs in such courses? It is my opinion that to such a question there is only one answer which can possibly hope to enable engineering education to meet the challenge of the rapidly changing and growing complex of requirements which it must satisfy. Physics, along with other science courses, should provide sufficiently deep and strong scientific roots to make possible healthy professional technical growth in whatever area of engineering a student chooses to cast his career. This calls for the elimination practically in toto of applied physics in physics courses for engineers. I realize that this view is diametrically opposed to the traditional role of science in engineering curricula and hence it is bound to be unpopular. But even were it wise to urge physicists to teach applied physics (and I believe that engineering teachers are the ones who are best suited to teach applied science), the rapidly growing body of scientific knowledge, the equally rapid decrease in the time interval between a discovery in pure science and its practical utilization, and the unprecedented rate at which modern physics is making itself felt in technology and industry, would mitigate strongly against such a course of action.

Pure Physics

In short, physics courses should be pure physics and applied physics should be taught by the engineers. If, and I shudder to contemplate such an event, applied physics represents all that would be desired in engineering curricula, then it should be taught entirely by engineers. Such an attitude would inevitably result in vocational training rather than engi-

neering education. Let us banish such thoughts from our discussion and face the following issue squarely: "How can physicists meet the challenge of imparting a strong and deep base in physics, including modern physics with all its rapid growth and increasing abstractness and complexity, without having available any appreciable increase in time to do the job?" Clearly, the mere addition of the factual matter of modern physics and of modern physical theory to the traditional courses can lead only to dilution and superficiality. I submit that we need surgery; we must be willing to cut out much of the traditional, albeit solid, subject matter of physics, use modern physics to supply the illustrations of the basic principles, shift the emphasis to the broad conservation principles and their implications, integrating them into a unified structure, and drop the conventional divisions of physics. These are harsh remedies, but no longer are they a matter of taste; failure to employ such remedies can only lead to a deterioration in the well-being of the patient.

I do not pretend to know just how to perform the surgery which is called for. In fact, there may be and probably will be a number of adequate solutions, equally good, in attaining the ultimate goal. It will be well if many solutions do exist, so that individual teachers can follow their own tastes and be guided by the interests and caliber of their own students in choosing the best course for them. In any event, one thing is clear; we must face this educational problem in the same spirit that we face any new problem in science. An objective experimental attitude devoid of prejudices, a willingness to learn by failure as well as by success, and an awareness that this type of problem constitutes a continuing research program for teachers at every level, are the necessary ingredients for clarification and progress in this otherwise perplexing and discouraging situation.

February 25, 1954

The Responsibility of the Physics Teacher in Engineering Education

By LLOYD P. SMITH

Cornell University

The matter of situations and problems to be faced by the teacher of physics for engineering students and the effect of his teaching on the technical competence and aims of the engineering student is fraught with complicated difficulties. This is evidenced by the continual discussion, the unhappiness on the part of some engineers about the teaching of physics, the threats to remove the teaching of physics from competent teachers in physics departments and replace this by the teaching of physics from the engineering or practical point of view within the college of engineering.

In my opinion, one of the most important reasons for this continuously unsettled state and lack of mutual satisfaction in this matter is due to a lack of mutual understanding of what the true objectives of engineering education and training really are in various schools. This arises in part because there is evidence that a good deal of uncertainty and confusion exists within a given engineering school in regard to the type of training it is expected that engineering graduates will on the average acquire. It is not possible to discuss the responsibility of the physics teacher in engineering education in an enlightened way unless one sees clearly the

objectives to be achieved by engineering education in various schools of engineering. It is fairly clear that the responsibility of a physics teacher is one thing if the engineering school under consideration really wants to turn out technically qualified engineers, and it is another thing if a school wishes to turn out students who will be qualified mostly for routine design, directed staff work, engineering sales and other applied specialties. Since I believe that a modern engineering college located within a university has the responsibility of providing the type of training which will turn out technically qualified engineers, I shall discuss the responsibility of the physics teacher on the assumption that it is the latter type of educational objective toward which a particular engineering school is striving. Before doing this a word or so is necessary to define what I mean by a really technically qualified engineer. The most important measure of a technically qualified engineer is the degree to which he can analyze and reach important technical decisions in non-routine engineering or technical situations. I am assuming therefore that he will have the ability to do considerably more than carry out routine designs of new structures or to handle repetitive engineering situations.

This ability to analyze a situation and bring to bear an extensive technical knowledge on the solution of modern problems differentiates the ordinary engineer from the productive and outstanding one. The basic physics which a student acquires and really understands has a direct bearing on this analytical ability. There is evidence that at present this ability on the part of a student increases rather rapidly during his first two years in engineering school and increases but little in the remaining college years. To the extent that this is so, the engineering training in later college years is deficient. If we take it for granted that it is desirable to develop this analytical ability during the course of an engineer's training, it becomes the important responsibility of the physics teacher to provide the student with a firm foundation of basic physics. He must not only supply him with the factual knowledge of the science, but most important of all he must inculcate the seeds of analytical skill, that certain something which allows an individual to first obtain a clear understanding of a situation and proceed to scientifically and technically sound conclusions about it. This is a particularly difficult thing to do at the present time. Much of a student's pre-college training these days places more stress on being able to give back to an instructor the material which is presented to him by means of a book or lecture. In other words the student is coached more than taught. Very little emphasis is laid on the analytical approach which I have just mentioned.

Poor Study and Work Habits

In preparing for college in this era, many students not only do not do very much thinking in contrast to memorizing but they have extremely poor study and work habits. This makes the task of the physics teacher in realizing the responsibility mentioned above all the more arduous. It seems to me that one of the most important things to do is to find a means of taking the rather poorly prepared student and providing him with the type of training mentioned above during his college career. A re-distribution of subject matter as between mathematics, physics, and chemistry may be required to realize this objective.

It is my firm opinion that mathematics, physics, and chemistry should be taught in these respective departments by teachers competent in their fields, who along with the engineering faculty have a clear understanding of the objective of the engineering school and the role that science is to play in realizing these objectives. I have no objection per se in transferring material in physics to schools of engineering when these subjects become more of the nature of applied subjects which are not necessary or particularly important in establishing the basis for a clear under-

standing of physics nor play an important role in developing the analytical ability of the student. This transfer has occurred before. For example, nowadays very little circuit work is done in physics but has become an integral part of the training program in electrical engineering. To take the basic work in physics, which is so important in the understanding of phenomena and important in developing the student's analytical ability into schools of engineering, is, I believe, quite the wrong thing to do. One reason advanced for transferring the teaching of mechanics, heat, electricity and magnetism and elasticity, etc. to engineers is that the only current research in these topics is being conducted in engineering schools and the most stimulating instruction will be given by instructors closely associated with such research. As far as stimulation and up-to-date instruction goes I would agree but I can not agree that all research in these fields, as I understand the term, is now being carried on by engineers. It is true that engineers are measuring heat transfer coefficients for numerous materials at a variety of temperatures, determining magnetic properties of materials, determining the properties of materials under stress and the like but what about the large amount of research concerned with the atomic and electronic mechanisms involved in the transfer of energy in matter, or the quantum behavior of atoms and electrons in matter which gives rise to ferromagnetism and properties possessed by ferrites or the migration of atoms which produce dislocations and their subsequent motion when a material is stressed leading to plastic flow, creep and the like, being carried on actively in a good many departments of physics? From the standpoint of basic understanding I do not think that this reason for transferring the teaching of the subjects mentioned above can be made to hold up. Another reason for making a transfer is to prevent overlapping and repetition of subject matter and to free more time in the student's curriculum for modern physics. The facts in this matter, as far as I know them, are that a really useful working knowledge of modern physics could not be given under such circumstances because the basic aspects of the subjects given in engineering, together with the concurrent development of the analytical approach is simply missing. Consequently the departments of physics would be required, of necessity, to build up the basic aspects of the subject anyway in a later period in the student's college course, at a period where most engineering schools have a full course schedule of their own specialties. If the objective in giving modern physics is to give a rather descriptive account of a group of phenomena in atomic and nuclear physics, this could probably be done. But the student would not obtain a working knowledge of modern physics which would be of much use to him in coping with the complex technical problems of the present day.

Training For Industrial Research

So far I have been speaking about the physics teacher's responsibility in the training of the usual engineer but not his responsibility or even the role of physics for the person whose career is to be in industrial research or advanced engineering development. The type of training required here is different from the usual engineer's training. This was very fully realized during the war, and as a result several new types of training programs have been established to fill in this gap. The answer to this type of training I believe lies in the establishment of engineering physics or engineering science curricula, where the emphasis is laid on the integration of three main technical areas: the basic sciences of physics, mathematics, and chemistry; the physics chemistry and metallurgy of engineering materials, generally; and engineering practice.

In this type of program the responsibility of the physics teacher is very great indeed. He must give the student in this program the opportunity to acquire an ex-

tensive knowledge of basic physics and help him to develop analytical ability to a high degree. In the Cornell engineering physics program this is accomplished in at least 36 hours of physics including a two-year course covering mechanics, wave motion, sound, heat, electricity, magnetism, and light, together with courses in thermodynamics and kinetic theory, analytical mechanics, atomic and nuclear physics, electronic properties of solids and liquids, advanced laboratory, and mechanics of continuous media. In this highly integrated program, the students fully realize from the very start that a good and thorough working knowledge of basic science is an important and integral part of their training. As time progresses they become even more fully aware of its potential usefulness in their work. In order to realize the objectives of this program, it would be quite impossible for the students to acquire their basic physics from courses in physics taught in the engineering college from an engineering point of view.

The most important point I wanted to make here is that for a competently trained engineer it is essential that he acquire sound basic knowledge of our most basic science, namely physics. And he must be helped to develop the analytical approach which is natural in physics. This I feel can best be done by association with people trained in physics within the department of physics. The success of a physics teacher in doing this depends on a clear and understanding knowledge of the engineering school's objective and his ability to cope with the inadequate preparation and working habits of our present-day students now entering the universities.

Physics for Engineers in the Mid-Fifties

By L. E. GRINTER

University of Florida

Physics has undergone a remarkable transformation in the past twenty five years. Engineering has passed through an equal or even greater change. Yet the physics taught today to engineers except in a few locations could have been taught and in the most enlightened spots was probably being taught in 1930. It is difficult to understand that this is in the best interests of the engineering profession. However, to reach a conclusion as to what approach to physics would be in the best interests of engineering education will require long soul searching and a far deeper analysis than this brief paper can be expected to make. Engineers will be satisfied if they see their colleagues in physics undertaking to determine cooperatively what physics should be taught to engineers in the mid-fifties. Of course, this is not a decision to be arrived at either by physicists or engineers working alone. It must be a cooperative endeavor, but the engineers would prefer to see the study spearheaded by physics teachers.

Increased Use of Engineering Science

We need not review the changes that have occurred in physics during the past fifty years, but the changes in engineering may not be so well understood. Engineering art is as ancient as civilization, but engineering science is not much more than a century old. It is little more than a hundred years since Squire Whipple developed the procedure of stress analysis for a simple truss. As pointed out by N. W. Daugherty, Mahan's textbook, "Civil Engineering," published in 1846, which was in use until nearly 1900, significantly does not give a method of cal-

culating stresses in trusses even though it has chapters on bridges and other structures. During the second half of the nineteenth century, when the pattern of the typical course in physics for engineers was being evolved, engineers were almost wholly dependent upon physicists for their background of science.

As is well known, engineering colleges evolved from departments of physics or of natural philosophy. In such early years engineers naturally looked toward physics as the source of their limited tools in engineering science. The physicists' struggle for recognition in the academic fraternity paralleled their own struggle. The eventual academic recognition of physicists foreshadowed the recognition of engineering as a learned profession. The evidence of recent years that engineering and physics consistently attract the highest student intellects to their curricula has broken down the last academic barriers. In many respects physics and engineering are one branch of learning but with different objectives and different emphases.

Throughout the nineteenth and the early part of the twentieth centuries engineers were able to apply engineering art to produce great advances without feeling the need for much engineering science. Elementary statics, dynamics, thermodynamics and electricity from physics served as a scientific background which most engineers used only intuitively to guide their applications of engineering art. Mathematical analysis was given scant attention in engineering offices. However, a slow growth in the importance of science in engineering was taking place. This influence led to the teaching of additional mechanics to civil engineers and somewhat later to additional thermodynamics for mechanical engineers. Electrical engineering was born with a stronger scientific interest than the older branches of engineering. Correspondingly, when chemical and aeronautical engineering developed, their curricula emphasized the viewpoint of applied science rather than art.

Research in Physics and Engineering Science

Graduate study and research in engineering showed a parallel growth. It appears that a Ph.D. degree given in civil engineering at Cornell soon after 1870 may prove to be one of the first doctor's degrees conferred in the United States. In any event, it indicates an early development of the spirit of research in engineering colleges. Since the engineering departments could not control the extensive procedures necessary to produce advances in the art of engineering, most research and graduate study was initiated in the fields of engineering science, i.e., in statics, dynamics, thermodynamics, fluid flow, heat transfer, electrical circuits, fields and electronics, physical metallurgy and the study of engineering materials. In early years, these studies duplicated rather heavily the interests of physicists, but the volume of research to be accomplished demanded the available manpower from both fields.

Depending upon whether one talks with electrical engineers or with physicists, electronics became a field of engineering science at some time between 1930 and 1940. Physicists had made many of the early contributions and many physicists continue to work in this field, but the large volume of electronics research both basic and applied now appears to have its primary source in engineering. Of course, electron physics is of primary interest to physicists. At one time the major research in elasticity, plasticity, elastic stability, fluid flow and heat flow came from departments of physics. One now turns to engineering journals for the large volume of research work in these fields. As an example, the *Journal of Applied Mechanics,* sponsored by ASME, is the most fruitful American source of theoretical research papers in mechanics. This journal was only established some twenty years ago.

It seems clear that physicists maintained a strong interest in and produced a major influence upon most of the fields of engi-

neering science until World War II when the research interests of so many physicists was reoriented by the development of nuclear energy. At that time one observed the transfer of the interest of physicists to contracts of the Manhattan Project, the disappearance of physicists without even a forwarding address, the closure or transformation of laboratories. Some of the previous researches of physicists were taken over by engineers. Elsewhere, in engineering the pressure of military need backed by unlimited funds led engineers to attempt to solve problems in engineering science which otherwise might have been left for leisurely solution by physicists. Once engineers found that they could also move forward the curtain of the unknown in those fields of science that form the immediate background of engineering practice they have shown no desire to withdraw. In fact, engineers have steadily increased their productivity of rather fundamental research in the engineering sciences.

The Contributions of Physicists to Engineering

It is fruitless to try to guess to what degree the interest of physicists will eventually be returned to the fields of engineering science. Clearly, the emphasis upon nuclear and particle physics and other fields of modern physics cannot be permitted to die or even reduce appreciably. Those agencies that finance research in the fields of modern physics will see to that. Research manpower is short in engineering, but there is very little hope that I can see for help from physicists. Instead, the number of engineers devoting their time to research in the engineering sciences is certain to increase slowly. In short, for those fields introduced in the typical one-year course in classical physics for engineers, the volume of relatively basic research produced by engineers appears likely to far outweigh the possible research of physicists. It also appears that engineers now inherently recognize their responsibility for research, both pure and applied, in the fields of engineering sciences. Conversely they recognize their dependence upon physicists for further knowledge of the nature of matter and of gravitation, energy and force.

It is this feeling of complete dependence upon physicists for the most basic concepts in engineering that has led well known engineering educators to question the traditional course in classical physics for engineers. ASEE has been trying to develop a pattern of engineering education to prepare engineers for scientific leadership twenty-five years hence. To put the matter in its simplest terms, engineering teachers have a chance to observe every engineer who completes the course in physics and they do not feel that these students carry with them sufficient basic knowledge of the nature of matter or of the molecular and crystal formation of materials or of gravitation, energy or force. Instead, the student carries to his engineering courses a slight knowledge of equilibrium, motion, heat and electricity and an even more casual understanding of light and sound. This understanding is so limited and so uncoordinated with engineering terminology and engineering thinking that I fear a majority of engineering teachers in mechanics and thermodynamics and even in electricity give the work in physics little weight or direct consideration in planning their courses. Hence, we have unplanned duplication in a short curriculum where every moment of classroom time is as precious as a drop of water in the desert.

Reduction of Educational Duplication

If duplication were the only question involved, it could be reduced if not avoided by engineering teachers themselves. Or more effectively, physicists and engineering teachers could meet together in regularly scheduled conferences to eliminate undesirable duplication. However, one doubts that anything less than a planning conference every semester could

achieve and maintain any real semblance of coordination between the teaching of a dozen physics teachers and fifty or more engineering instructors who receive the product of physics instruction. Such coordination becomes a problem of great complexity. Two colleges are usually involved. Tradition is rampant. Up to a third or more of the instructors involved may change in a single year. There are objectives beneath the surface that influence attitudes unduly. For example, physicists unhesitatingly admit that the loss of teaching hours for their graduate assistants in handling sophomore engineers would handicap physicists' research. Engineers too often approach the problem of coordination with the preconceived notion that anything a physicist can do for an engineering student can be done better in an engineering class. Such viewpoints must be met and overcome.

Teaching Modern Physics to Engineers

There is something of far greater importance than relieving duplication to be accomplished by a modern approach to physics instruction for engineers. Physicists, particularly young physicists, do not hesitate to say that after a first or second experience the teaching of classical physics to engineers becomes a chore. Some older teachers take a reversed viewpoint, but it is clear that these indivduals are valuable professional teachers to whom subject matter has become of less importance than teaching procedures. We need such able teachers. They can present equally well more modern subject matter even though they may not be research workers themselves. Although the sophomore or junior engineer is not ready for graduate work in physics, he is fully able to acquire a useful knowledge of nuclear physics and physics of the solid state when presented at an appropriate level. It should not be forgotton that engineering students, on the average, have minds fully equivalent to those of science majors and that no watering down of scientific content should be necessary in a physics course for engineers.

The Committee on Evaluation of Engineering Education of ASEE has concluded with remarkable unanimity that a knowledge of modern physics is essential for engineers. Doubtless, physicists generally will applaud this decision. Doubtless, too, most physics teachers would recommend an additional year of physics study to accomplish this objective. Unhappily, that approach is not likely to accomplish the objective of an understanding of modern physics for engineers as long as the four-year curriculum continues with its strong limitations upon time for the study of any individual field.

Individual Solutions Necessary

It is not possible for anyone to devise a universal solution to the problems that have been presented. There are more than a hundred and eighty institutions with accredited curricula in engineering. There are many variations in the way physics is taught to engineers. Each institution must study the matter and devise its own solution to the need of engineers for a knowledge of modern physics. Certainly a real attack should be made on the factor of duplication with contributions and concessions from both engineering teachers and physics teachers. It appears that a logical criterion for determining where a given topic should be taught can be found in the main source of the research in the field. If it can be demonstrated that the research in a given field is being conducted largely by physicists there need be no fear that engineers can or will desire to take over the undergraduate instruction therein. The department that is responsible for the research in a given subject should produce the greatest stimulation of either undergraduate or graduate students in that field.

The conflict that one sees in the present situation is that the subjects of greatest interest to physicists and in which they are so intensely involved with research are

not being taught to undergraduate engineers. Nuclear and particle physics and physics of the solid state are left for study by physics majors and by graduate students. A very large percentage of engineers graduate without contact with these subjects. It seems to me that the opportunity to teach these subjects to engineers would provide a real stimulation not only to the engineering students but to those physicists who find the teaching of mechanics, thermodynamics and electricity at the most elementary level a little dull.

The Basic Values of a Study of Physics by Engineers

As adjustments are considered engineers should be quick to agree that there should be no reduction in the total time which engineering students should give to study within departments of physics. In fact the Committee on Evaluation of Engineering Education has recommended that added time be devoted wherever possible in engineering curricula to the study of the basic sciences. The present amount of time devoted to physics is a minimum for indoctrination of engineers into the thinking, the viewpoints, the attitudes, and the research methods of physicists.

The subject matter in physics of greatest value for engineers will be that subject matter which acts most effectively as a vehicle for teaching the viewpoints, attitudes and methods of modern physics research. A second reason why the engineering student needs a working relationship with modern physics is that it will be his job a decade or two decades later to devise the processes, mechanisms and plants that will put modern physics to work for the welfare of mankind. Only with humility and understanding can we properly approach our joint responsibility for achieving an education for engineers in the mid-fifties that may bring forth a new industrial revolution.

The Responsibility of the Physics Teacher in Engineering Education

By HOMER L. DODGE

President Emeritus of Norwich University

The problem of the relationship between pure and applied science has been with us for a long time; and it will remain so, for it is one of those problems for which there is no perfect or final answer. The best that can be expected is a *modus vivendi* between physicists and engineers resulting at any given time from whole hearted cooperation and a willingness to give generous consideration to differing points of view. It is natural that there should always be persons whose primary concern is the application of science for useful purposes and other persons whose interest lies primarily in science for its own sake. Fortunately there will be others with varying degrees of interest in both fields; but both engineering and science would suffer if there were not those to which one or the other is the burning concern.

With this situation, there is no possibility that either group will have the last word or find a way for working harmoniously with the other that will be completely satisfactory to it. In their dissatisfaction the engineers are tempted to take over the teaching of physics and so remove the teaching of the subject from physicists closely associated with, and participating in, the current developments of their science as a living subject. Engi-

neers know how essential it is that engineering teaching be carried on by men who spend part of their time in active engineering practice; they should realize that science also must be taught by persons to whom it is a vital living thing. It is the fault of physicists that those engineers who appreciate this fact are rightfully disappointed in the way in which physics is currently being taught to engineers. And the AAPT merits criticism for not having accomplished more in vitalizing the teaching of physics to engineers in the twenty-four years of its existence.

The cure will come when engineering educators make up their minds wholeheartedly to devote a major part of their efforts toward turning out really professional engineers. There has been little evidence of such a desire, for it demands more of a reorganization of American engineering education than engineering educators have been willing to undertake. That it has not been more seriously considered is surprising, for the model from which lessons could be gained, even though it might not be desirable to emulate it in all details, has existed in Europe for years.

Principles vs. Practice

In the summer of 1926, I made a study of engineering education in Europe, visiting some dozen or more of the leading institutions in England, Denmark, Germany, Austria and France. Everywhere I was impressed with the fact that engineering in Europe is regarded as applied *science*. One sought in vain for anything like our departments of civil, electrical or mechanical engineering; but had no difficulty in finding great departments of mathematics, physics and chemistry where the students spent their time learning the fundamental science upon which all engineering must be based. In the laboratories the emphasis was on *principles* of engineering rather than on *practice*. It was explained that no educational institution could possibly keep its equipment up to date sufficiently so that students could learn current practice; so they were content to make the students sufficiently familiar with heavy machinery so that they would not feel too strange when confronted with the actual work of their first jobs.

I suppose it was from this experience that I formulated the principles that were applied so successfully at the University of Oklahoma in our engineering physics curriculum which was devoted largely to preparation for geophysical prospecting for oil.

In our curriculum, including graduate work, there was only one course that was not a regularly offered course in physics, mathematics, geology, engineering or other subjects. This was a three-hour, one-semester course in applied geophysics. For this course we had available excellent field equipment, but we told our students that there was something wrong with the company if, when they got their first job, they found still in use any of the equipment we had been able to show them. And that if, in the course of a year, they had not made obsolete the equipment and methods which they found on arrival, there was something wrong with them or the preparation we had given them. Our better men were soon operating their own companies or organizing instrument companies to manufacture equipment of their design.

As already suggested, we can learn a great deal from European engineering education, but its spirit and methods should be used to supplement and correct our methods rather than as a substitute. There is an ability, energy and drive, that American engineering graduates have, to *get things done* that is not to be found in Europe. This came out in a conversation with a German professor who would not let me forget the virtures of our American way. "Our men," he said, "are better trained than yours, but they are so thoroughly trained and so scholarly in their approach that they seem never to be quite ready to do the job. There is always some additional refinement that must be made before they start. Our graduates can

make almost perfect designs for bridges and dams but somehow they don't get them built. On the other hand, your graduates, inadequately prepared for many of the projects that they undertake, do manage to work out designs, doubling the factor of safety with the hope that it will take care of their deficiencies, and get the structures built. Luckily, not many of their bridges fall and not many of their dams go out with the first flood. Something that combines what you have in America and what you have discovered we have in Europe is what you need to make American engineering the foremost in the world."

As a member of the ASEE for over twenty-five years, I have observed no serious attempt to develop a program for the education of really professional engineers on an equal footing with physicians, lawyers and ministers or, for that matter, men trained in the disciplines for which the degree of doctor of philosophy is regarded as a professional prerequisite. In none of these fields is the attempt made to build a professional education on a high school preparation. And yet that is what engineering educators are still trying to do.

Some of the leaders, realizing its inadequacy have been playing with the fifth year, others have been trying to make up for general cultural inadequacy by doses of a few 3-hour "Social Studies" pills while others have been pressing for "research" and "graduate study," not realizing that the usual four-year engineering course furnishes no sound foundation for genuine graduate study and research.

With other professional fields dissatisfied with any preparation less than a sound, broad liberal college education, with a grounding in the fundamentals upon which the profession rests, whether they be natural science, political science, or philosophy and psychology, engineering has persisted in the fallacy that professional engineering education can follow a high school preparation.

Inadequacy Being Recognized

It is true that the inadequacy of the present course in engineering as a foundation for graduate study is being recognized in the talk about a professional-scientific course. But the total inadequacy of graduate work founded on such a course to produce professional engineers able to stand on an equal footing with other well trained professional men has not been brought out.

Thanks to the imagination, energy and persistence of American youth, many of them have found their way to a solution of this problem that has been so baffling to experienced engineering educators. Finding out for themselves the inadequacies of their engineering preparation, they change over into mathematics, physics or chemistry for graduate work. Or it may be that they finish an undergraduate program in physics or mathematics and, feeling the urge to go into applied science, seek out one of the engineering colleges that lead in graduate work. Others plan from the beginning what the engineering educators should plan for all who are expected to become truly professional engineers. Knowing that they want to be engineers, but that they also want to be educated men, they first complete a college education and then move into engineering, or perhaps they take advantage of a transfer to an engineering college at the end of three years, as has wisely been provided for by some institutions. And finally, a very small number of prospective engineers enjoy the excellent professional preparation provided by curricula in engineering physics (or the equivalent) which, for over a half-century, all too few departments of physics have had the imagination to provide. But this group is not the subject of these remarks.

Fundamental Change in Approach Needed

If I had at my command several million dollars, I could think of nothing better to do with it than to found a graduate school

of engineering. The requirement for admission would be graduation from a liberal arts college, with a reasonable amount, but not too much, mathematics, physics and chemistry. Properly staffed and equipped, such an institution would produce real professional engineers, and its influence on engineering education would be profound. No combination of "professional-scientific" and graduate study is going to produce the equivalent. Insofar as any program of engineering education fails to do this, it will fail to provide true professional training.

When programs of this general type have become the ideal of engineering education, physics will not have to be concerned about its place in engineering curricula. Until such a fundamental change in approach is made, however, engineering educators will continue to try to effect a cure by treating symptoms of a disorder instead of getting to the root of the trouble.

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Engineering Education,
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Report on ASEE Summer Institutes on Inclusion of Modern and Solid State Physics in the Curricula of All Engineers

By CLIFFORD BECK

Head of Physics Department, North Carolina State College

Four separate conferences jointly sponsored by ASEE and NSF, each composed of engineers and physicists from industry and academic institutions, were held in the summer of 1954. Two of these conferences dealt mainly with the advisability of including a portion of basic, elementary Solid State Physics in the curricula of all engineers. The other two dealt with the same question relative to Modern, Atomic, and Nuclear Physics.

In each of the two series of conferences, the first was a "Closed Conference" limited to about 30 invited participants who acted as an exploratory survey team to identify and select matters of importance in the general area of interest, and thus to define an agenda for the subsequent Open Conference of volunteer participants in the subsequent meeting. The two Open Conferences were each attended by 125–150 scientists, engineers, and industrial representatives.

The Open Conferences were four days in length. Formal presentation of opinions and suggested materials by top-level scientists and engineers from all over the country alternated with discussion periods —which were most vigorously utilized.

The discussions were by no means limited to the topics which might be considered closely related to the central theme. Individual opinion ranged almost from the one extreme of eliminating all physics from the curricula of engineers to that of eliminating all engineering courses from the curricula of engineers!

On the other hand, the topics relevant to the main problem of modernizing and reassessing the scope of chemistry and physics which might desirably be included in the curricula of all engineers, did receive lengthy consideration, and there was surprising unanimity of agreement on the major conclusions reached by the conferences. These conclusions, as recorded below, are chiefly those characterizing the opinions deriving from the Open Conference on Modern Physics. It is understood that very similar conclusions were arrived at by the Conference on Solid State Physics.

1) It was heartily reaffirmed that incorporation of the *methods* and *techniques,* as well as the basic principles and subject matter of chemistry and physics, is essential in the training of engineers. It was felt that re-orientation of presentation of the subject matter of these basic subjects to resemble the presentation used by engineers would defeat the major values of the courses.

2) It seemed inescapable that the scope of chemistry and physics today is much greater than it was a few years ago. There derives immediately from this fact a choice of two alternatives: (a) expand the general physics courses so that adequate attention could be given to more subjects, (b) arbitrarily eliminate some subjects and concentrate more attention on the ones remaining.

The conclusions of the conference represented, as might have been anticipated, a

compromise between these two alternatives.

A. Opinions on revision of general basic courses fell into two categories:

(1) eliminating or minimizing subjects not related to fundamental principles and not essential to development of subsequent concepts, and (2) modernization of illustrative examples and inclusion of up to date problems from modern physics and chemistry. It was the general consensus, however, that sufficient curtailment of basic classical physics to permit inclusion of adequate amounts of modern physics could not be done without serious compromise of objectives.

The discussion of modernization of the basic chemistry course, by Dr. Linus Pauling, contained the major thesis that the approach today should be from the viewpoint of *structural concepts,* based on current knowledge of *atomic* components and behavior. This is in contrast to the *descriptive* approach to chemical reactions widely used, formerly and currently.

B. Addition of new material, beyond the scope normally included in an up-to-date first course in general physics.

It was recommended that subject matter of a scope roughly equivalent to a 3-semester hour course on topics in Modern Physics such as those listed below be included above the general physics course level in the curricula of all engineers:

(1) Atomic Structure of Matter
  (a) Kinetic Theory
(2) Fundamental Particles
(3) Quantum Theory of Light
(4) Atomic Structure
  (a) Energy Levels
  (b) Spectroscopy
  (c) Periodic System
(5) X-Rays
(6) Wave Nature of Matter
  (a) One Dimensional Wave Equation
(7) Atomic Nucleus
(8) Molecular Structure
  (a) Valence Bonds
(9) Nuclear Structure—Elements, isotopes, elementary particles
(10) Binding Forces
(11) Binding Energy Curve
  (a) Mass-Energy Relation
  (b) Radioactivity
  (c) Nuclear Reactions
  (d) Fission, Fusion
(12) Neutron Chain Reaction
  (a) Heat—Power
  (b) Radiation—Interaction with matter
    Radioisotopes
    Breeding
  (c) Fission Products

It was also recommended that subject matter of a scope roughly equivalent to a 3-semester hour course on the topics in Solid State Physics listed below be included above the general physics course level in the curricula of all engineers:

(1) Crystal Structure
(2) Binding Forces and Crystal Types
(3) Mechanical and Thermal Properties
(4) Electrical Conductivity
  (a) Metals
  (b) Semiconductors
  (c) Salts
(5) Dielectric Properties
(6) Magnetic Properties
(7) Surface Effects
(8) Phosphors and Photoconductivity

(3) The strong suggestion of Dr. Pauling that basic chemistry be approached from a structural concept basis, with considerable prior effort being devoted to the necessary principles of atomic structure and electron behavior, the obvious necessity of including atomic structure and electron behavior in general physics, and the recommended inclusion of this same material in further detail at a higher level, led to some suggestions that collaboration of chemistry and physics teachers at the outset might lead to satisfactory instruction in these topics without undue overlapping and repetition.

(4) There was apparent in the conference a strong opinion favoring em-

phasis on basic science and basic engineering training at the undergraduate level, to the exclusion of courses related to specialization in restricted fields. Several serious opinions were expressed that attention should be given to *one* common undergraduate curriculum, containing a fair latitude in elective choice, of course, for *all* engineers. No dissent from these opinions, or from others proposing a common curriculum for at least three years, was voiced. By these plans, specialization and diversion of interests would be provided at the graduate level or by industrial companies after employment of the student.

(5) There was little dissent from the opinion that there is now no unique combination of activities which would distinguish Nuclear Engineering as a separate professional category. Instead, it was recognized that what is now called Nuclear Engineering is largely the application of orthodox engineering practices to a new technological area. It was also recognized, however, that some percentage of engineers practicing in this new area, variously estimated at 1% to 15% by 1970, would require training in nuclear processes and techniques beyond those generally provided for engineers. Further, it was noted that there is spontaneous and spreading use of the designation "Nuclear Engineer" even to the extent that several professorships in Nuclear Engineering have already been established.

Nevertheless, it was commonly agreed that establishment of a specialized course of study in Nuclear Engineering at the *undergraduate* level would be contrary to the recommended trend toward less emphasis on specialization at this level. It was the opinion instead, that such special training as would be needed, for as many men in this new area of application as might be required, should be provided at the graduate level.

The specific recommendation was, that "all *engineering schools* should give continual attention to the possibility and need for professional education in nuclear technology, especially at the graduate level."

Two factors were identified which tend to conserve the present over-emphasis on specialization in training of engineers at the undergraduate level: (1) the status quo of strongly established administrative lines on fields-of-engineering departmental basis, and (2) the insistence of employers in hiring graduating students according to specified engineering categories.

Comments on Nuclear Engineering in the Open Conference

It is our experience in our programs at North Carolina State College, and is in accord with our general opinions on engineering education, that development of nuclear engineering subjects and techniques in the training experience of students is most desirably provided at the graduate level. The sequence of an undergraduate training in some usual science or engineering field, followed by a master's program in Nuclear Engineering, constitutes an optimum combination. In general, as might be expected for such transfer students, it has been found that more than one year, and sometimes two, is required for completion of a satisfactory master's program in Nuclear Engineering. Preparatory courses in basic science and mathematics for the engineers and in essentials of engineering for the science students are usually required before the serious courses in applied nuclear processes are scheduled.

The general theoretical opinion of engineering educators today is that more basic scientific and generalized engineering training is needed at the undergraduate level for engineering students. The author of the undergraduate curriculum in Nuclear Engineering at North Carolina State College strongly concurs in this opinion, though, superficially, the designation of a course of study at the undergraduate level as Nuclear Engineering might appear to be the converse.

Actually, as has been pointed out in several ASEE and other meetings (Fon-

tana, Oak Ridge, Ann Arbor, Northwestern), the undergraduate curriculum designated as Nuclear Engineering contains more basic science and general engineering courses, and less material of specialized nature than can be found in almost any other engineering curriculum. The course distribution more closely approximates what might be called Engineering Physics than one of the usual engineering curricula.

Despite this however, there still seem to be very strong reasons for maintaining, at least for the present, the designation of this undergraduate program as Nuclear Engineering.

(1) This designation has strong attraction and motivation influences on the students. The course is well known to be "tough" but above-average students in increasing numbers are attracted, and the challenge of endeavor in an area of technology called Nuclear Engineering seems to have significant incentive value.

(2) The employer demand for students with "Nuclear" designation greatly exceeds the supply, and salaries significantly higher than obtained by other engineering graduates are offered.

(3) The course of study is fundamentally a sound one, whatever its designation, and provides a commendable foundation either for further work at the graduate level or for adaptation into research or engineering teams of an employer.

Perhaps eventually the pessimistic views will be vindicated of those who hold that the advent of significant beneficent applications of nuclear processes will be slow in developing and minor in scope. I believe otherwise. The commitment our government has made to a major effort in development of power from nuclear fuel as an important factor in our international relationships, the urgency of the need for power in many countries which could potentially be fulfilled by nuclear fuel, and the infiltration of nuclear applications throughout our industrial enterprises as is sure to occur, together with the attendant new applications likely to develop, cannot fail, in my opinion, to present a continuing demand for men well trained for these tasks. Training for such men must include instruction in the particular subject matter and methods peculiar to applied nuclear phenomena. For want of a better name, the convictions of engineering pedagogy not withstanding, such men are likely to be called Nuclear Engineers.

For these reasons, at least until sufficient reason for other action appears, we shall continue to train students in the subject matter and techniques of applied nuclear processes, beyond their sound indoctrination in basic science and engineering disciplines, and shall likely call these men Nuclear Engineers.

ANNUAL MEETING—1955

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A Curriculum for Technical Editors?

By CHRISTIAN K. ARNOLD

Technical Editor, Ordnance Research Laboratory, The Pennsylvania State University

Probably the professional field most widely ignored by the colleges and universities of the United States today is that of technical editing and writing. To my knowledge, no school in the country offers a definite, integrated curriculum to prepare students for positions in this field.

It is difficult to see why this field is so largely ignored. Surely it is not because the field is too limited to justify establishing a curriculum for it. It is readily apparent that the technical editor has become an integral part of almost all organizations engaged in research and development. The tremendous number of such organizations is indicated by the estimate that more than $3 billions were spent in the United States in 1952 alone on research and development. In addition, technical editors and writers are needed by publishing firms, professional journals, trade magazines, and newspapers. In the field of "popular" writing, both of articles and of book-length publications, it is generally believed that the least crowded field is that of science and engineering, not because of a lack of demand for such writing but because of a scarcity of capable technical writers. The field, then, that would be served by such a curriculum is obviously larger than those served by many of our traditional curricula: the classics, archaeology, and anthropology, for instance.

The Sandia Corporation, the General Electric Company, and the Sperry Gyroscope Company are only a few of the organizations that have advertised nationally month after month in an effort to recruit technical editors and writers. A Civil Service Commission serving five government-operated laboratories on the west coast advertised for a technical editor at the GS-11 level ($5910 annually) for well over a year without finding a person capable of filling the position. A medium-sized eastern laboratory advertised nationally for a technical editor for several months and finally paid a man moving expenses from California in order to fill the position.

This need is easily explained. Engineers and scientists can no longer afford to write just for each other, if indeed they ever could. In fact, the demand for an ever greater degree of specialization makes it progressively more difficult for one scientist to understand another. At the same time, today's greater interdependence of the sciences makes it necessary for each scientist and engineer to rely on the works of others for the advancement of his own studies. In addition, because research and development have become such a big business, it is seldom possible for those who administer the programs to be experts in each of the many specialized fields represented in the programs for which they are responsible. To guide his decisions, the administrator must have reports that are not merely accurate but also understandable to him even if he is not an expert in the technical field involved. Science, too, is an important and dynamic governing force in our civilization, and the technically trained person has a grave responsibility to translate his work into general human terms.

Time Is Precious Commodity

Because the time of our scientists and engineers is one of our most precious commodities, it is foolish to require them to

be forever translating the processes and results of their specialized thinking into the common language. It is here that the technical editor and writer is most useful. He stands between the technically trained person and his readers (other scientists and engineers, the administrators, and laymen) a representative of both. His special job is to fill the gap created by the forces that make it, at the same time, more difficult and more important for the scientist to communicate with those outside his own particular field of specialization.

It should be noted that increased specialization increases the need for technical editors in still another way. The necessity for specialization has the effect of crowding training in composition into such a small corner of the technical curriculum that it is doubtful whether a Julian Huxley, a Ruth Benedict, or a Waldemar Kaempffert could be produced in our schools today.

The need for a special curriculum is emphasized by the confusion that exists among those who hire technical editors as to what they are looking for. This confusion arises because technical editing and writing require training in two areas rarely combined in a college career. A student majoring in composition or journalism, for instance, seldom takes enough hours in technical courses to convince a director of a research laboratory that he should be entrusted with the preparation of highly scientific documents for publication. On the other hand, students majoring in engineering or one of the sciences rarely take any composition beyond the freshman level, except, perhaps, one 2-hour course in report writing. Such training is obviously inadequate preparation for the job of editing of any sort.

This difficulty in finding adequately trained technical editors and writers has led to pronounced disagreements as to what one should look for when trying to find editors. Recently an administrative editor of a west coast laboratory flatly stated that an editor without an extensive technical background was of absolutely no use to him. On the other hand, Dwight Gray, head of the Technical Information Division, the Library of Congress, recounts that an editor with whom he worked during World War II performed "real editorial miracles with technical manuscripts" despite the fact that she had had no training in science.* The head of an editorial group at another west coast laboratory, who has worked in the past with editors trained either in English or in technical fields but never in both, has stated that his experience indicates the better editors are those with broad training in the liberal arts. Yet the advertisements of several large industrial laboratories indicate that a degree in science or engineering is required of their technical editors and writers.

These disagreements exist only because the combination of training indicated as desirable by the disagreements themselves cannot be found consistently. The man who received his training in technical fields will not be a very successful editor until he has mastered the tools of editing, regardless of the soundness of his technical background. No amount of natural fluency will qualify him without such training. Too, the man trained in composition cannot give maximum assistance to the scientists and engineers with whom he works if he does not understand their language and attitude and the fundamental concepts of science in general. The intelligent person with the desire to do so can become a successful editor from either original training, but such on-the-job training is inefficient both for the organization and for the individual.

Integrated Curriculum

An integrated curriculum could be devised rather easily to resolve all these conflicts, as the conflicts themselves indicate

* Dwight E. Gray, "Editing Technical Reports," Workshop on Production and Use of Technical Reports, Catholic University of America, Washington, D. C., April 13–18, 1953.

the subject matter of such a curriculum. The backbone of the curriculum would consist of thorough basic training in the tools of both the editor and the scientist: composition, physics, mathematics, and chemistry, as a bare minimum.

Courses beyond the basic ones of first-year composition, mathematics, physics, and chemistry would be selected or designed to give the student (1) a thorough training in the editorial tools needed by the technical editor, (2) a sympathy with and a working knowledge of the rules by which scientists and engineers work, and (3) a technical background sufficiently broad to enable him to follow intelligently the thought of the publication he is given to edit.

Skill in the use of language as a means of communication is, of course, fundamental and would necessarily underscore all other strictly editorial training. However, skill in communicating by various means other than language would have to be stressed somewhat more in the training of a technical editor than in that for other editors. Such means would include mathematics, photography, drawings, documentary films, and, especially, tables and charts. Special types of writing in which the technical editor would need training include progress and completion reports, articles for professional and trade journals, news and publicity releases, information and recruiting brochures, and documentary film scripts. In addition, the editor should be given a sound introduction to proofreading, the principles of layout and art work, methods of reproduction, technical photography, and methods of literature research.

On the technical side, a somewhat wider choice could be offered the student. Training in strictly technical courses beyond the basic tool subjects, especially in the particular field of most interest to the student, is absolutely necessary; but specialization secured at the expense of a broad training would be harmful rather than helpful. Courses in history, law, social science, economics, and philosophy, with particular emphasis on the role of science and engineering in our civilization, would perhaps be at least as valuable as the strictly technical ones.

Such a curriculum would not be difficult to establish in most of our colleges and universities. The job would be somewhat easier to accomplish in those schools in which a separate department of English is maintained in the school of engineering, because the necessary liaison between the ordinarily separated fields would have already been established. To be most effective, however, the curriculum should be set up at a school that maintains a fairly large research and development program. A situation of this sort would offer the advantages both of the experience and knowledge of working technical editors and of an editorial laboratory in which trainees could work on actual publications in a real-life editorial environment. Many colleges and universities are equipped today to carry out such a program.

Such a program would satisfy all the conflicting requirements for a technical editor, including that which Dwight Gray lists as a "must," the proper general attitude of the editor toward the scientist and engineer authors with whom he works.

Is Calculus a Perfect Tool?*

By KARL MENGER

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EDITOR: A specialized article of this type is somewhat of an innovation for the JOURNAL although it stresses pedagogy of the utmost importance. The reaction of the readers is invited to guide future decisions.

This paper describes a point of view adopted in an experiment in the teaching of calculus and its applications to science and engineering which, for the past three years, has been carried out at the Illinois Institute of Technology. Courses along the lines here described are offered only on an elective basis. The number of attendants averages fifty per term. The majority are students of mechanical and electrical engineering; next in number are mathematics and physics majors. The groups include a few beginners; most of the attendants had previous training in calculus along traditional lines; about one quarter are graduate students. Evening sections are attended by numerous engineers working in industry. At the end of the term, attendants are asked to turn in (anonymously) comments on the course. Practically all of them emphasize that their understanding of calculus and its applications has been greatly enhanced; in fact, many say that now for the first time they really see "what calculus is all about."

* * *

Calculus is one of the greatest of intellectual achievements as well as one of the most powerful of scientific tools. Masters of mathematics and science have used this tool with virtuosity; but they depended on their insight and experience; they did not describe all their procedures in articulate rules. Hence, in applying calculus to science, it is necessary to fill certain gaps in the process by use of intuition. A beginner's intuition is unreliable.

Six points which seem to be in particular need of clarification can be summarized as follows.

I. *The Equivocal Use of the Term "Variable"*

The letter x in

$$(1) \qquad \frac{2}{x^2-1} = \frac{1}{x-1} - \frac{1}{x+1}$$

is what mathematicians call a variable, more precisely, a *numerical variable;* that is to say, x stands for any number of a certain class of numbers, called the scope of x, namely, for any number $\neq 1$ and -1. Since the scope of a numerical variable is its only significant feature, x in (1) can, without any change of the meaning, be replaced by another letter standing for any number $\neq 1$ and -1 (say, by a). Moreover, x can be replaced by any number belonging to the scope (say, by 3).

The temperature of a gas, the distance travelled by a falling object, and the perimeter of a sphere are examples of what scientists and engineers call variables. We will refer to them as *variable quantities* (briefly, v.q.'s) and thus avoid an equivocal use of the term variable. Even though the temperature of a gas and the letter x in (1) belong to different worlds, v.q.'s and numerical variables have often been confused.

* Presented at annual meeting of ASEE, University of Illinois, June, 1954.

II. *The Lack of Mathematically Usable Definitions for Variable Quantities*

But what are v.q.'s? A v.q. assumes numerical values, and the class of all its values is called its range. However, that range is not the only significant feature of a v.q., since v.q.'s with the same range cannot, in general, replace one another. For instance, in the formula for the volume of a sphere, the radius cannot be replaced by the perimeter, even though both v.q.'s have the same range, namely, the class of all positive numbers.

A v.q., in contrast to a numerical variable, has also a domain. In the case of a physical v.q., that domain consists, primarily, of acts of specific observation. Each value of the v.q. is paired with such an act, the value being the numerical result of the act.

We will define a physical v.q. as a class of pairs of the form "act, result." For instance, the temperature, t, of a gas in degrees C. is the class of all pairs $(\gamma, t(\gamma))$ in which the first member, γ, is an act of reading a thermometer, calibrated in degrees C., and the second member, $t(\gamma)$, is the number read as a result of that act.[1] Similarly, the pressure, p, and the volume, v, of a gas in certain units are defined as classes of pairs $(\gamma', p(\gamma'))$ and $(\gamma'', v(\gamma''))$ of the type "act, result" of (manometric and volumetric) observations. The time elapsed since the beginning of a process is a class of pairs in each of which the first member is an act of reading a timer set in motion at the beginning of the process, and the second member is the numerical result of that act.

The abscissa of a point in a physical plane with a Cartesian frame of reference (such as a blackboard with two perpendicular chalk lines, a foot being the unit of length, or a modern city with a street and an avenue, a city block being the unit of length) is a geometrical v.q.; it is the class of all pairs $(\pi, x(\pi))$ for any point π of the plane, where $x(\pi)$ denotes the distance (in the chosen unit) between the origin and the projection of π on the first axis of reference. We denote this class of pairs[2] by x.

The preceding and countless other examples can be summarized in the following general definition. A variable quantity u with the domain A (where A is a class of elements whatever) is a class of pairs $(\alpha, u(\alpha))$ in which α is any element of A and $u(\alpha)$ is a number associated with α, called the value of u for α.

III. *The Lack of a Traditional Symbol for the Identity Function*

V.q.'s whose domains are classes of numbers are called functions. An example is the logarithm of a positive number, that is, the pairing of the number *log* x with any number $x > 0$ or, more precisely, the class of all pairs (x, *log* x) in which the first member, x, is any positive number. This v.q. is called the logarithmic function; it is frequently designated by its value for x, that is, as the function *log* x. But just as one uses the expression "log tables" rather than "log x tables" he may refer to the logarithmic function as the function *log* rather than the function *log* x and designate by *log* x the value of the function *log* for x.

Another important example is the square of a number, that is, the class of all pairs (x, x^2) for any number x. The "2" to the right above x indicates the square of x. But no one would understand a reference to the function "2". In fact, there does not exist any traditional symbol for the square function itself—apart from its value for x—nor one for the all-important identity function, i.e., the class of all pairs (x, x).

We will denote the identity by j and

[1] Physicists gradually extend the domain by including extrapolations and computations based on observations—operations leading eventually even to the temperature of the sun 2 million years ago.

[2] Clearly, the abscissa which we symbolize by an italic x is altogether different from the numerical variable in (1), denoted by a roman x.

the nth power by j^n. The values of these functions for x are $j(x) = x$ and $j^n(x) = x^n$; for instance, $j^3(3) = 9$. What is gained by the introduction of these symbols?

If $Df(x)$ denotes the value for x of the derivative, Df, of the function f, then the following formulae hold for any x (the second, for any $x > 0$):

$$\begin{aligned} &D\,sin\,x = cos\,x, \\ (2)\quad &D\,log\,x = j^{-1}(x) = 1/j(x), \\ &Dj^n(x) = nj^{n-1}(x). \end{aligned}$$

Here, x is a numerical variable and, just as in (1), x can be replaced by another letter (say, by a) or by a number of the range (say, by 3). In contrast, the traditional symbol $D\,x^n$ links the function and the numerical variable in such a way that x cannot be replaced by either a or 3. Therefore the values of the derivatives which we denote by $Dj^n(a)$ and $Dj^n(3)$ are traditionally symbolized by $(D\,x^n)_{x=a}$ and $(D\,x^n)_{x=3}$, even though one writes na^{n-1} and $n3^{n-1}$ rather than $(nx^n)_{x=a}$ and $(nx^{n-1})_{x=3}$, and *cos* 3 rather than $(cos\,x)_{x=3}$.

With the aid of the symbol j, functions and numerical variables can be separated throughout calculus, just as they have been in (2). In fact, one may, if he so desires, express the results of calculus in the form of relations between functions —the functions themselves, without reference to their values for x or, in fact, to any numerical variable—as in

$$\begin{aligned} &D\,sin = cos, \\ (3)\quad &D\,log = j^{-1} = 1/j, \\ &D\,j^n = nj^{n-1}. \end{aligned}$$

Similarly, the functions *sec* and *cos* can be related by the formula

$$\begin{aligned} &sec = 1/cos; \text{ that is to say,} \\ (4)\quad &sec\,x = 1/cos\,x \text{ for any} \\ &x = \pm\pi/2, \pm 3\pi/2, \cdots. \end{aligned}$$

IV. *The Lack of a Mathematically Usable Definition of Functional Dependence in the Realm of V.Q.'s*

Suppose that all values of the pressure, p, of a gas at 100°C. (written on tags) are collected in one bag, and all values of the volume, v, of a gas at 100°C., in another. The information about p and v contained in the two bags is confined to their ranges and would not permit the inference of a law connecting the two v.q.'s. In fact, Boyle took the domains of p and v into account. He paired acts of manometric and volumetric observations which are simultaneously directed to the same gas sample. He then discovered that for each such pair (γ', γ'')—no matter which sample was observed or when the two simultaneous observations were made—the volume $v(\gamma'')$ was the reciprocal of the pressure $p(\gamma'')$ multiplied by a certain number c (the same number c for all pairs): $v(\gamma'') = c/p(\gamma')$. This fact is expressed in the formula $v = c/p$. Instead, one may also say that, for each of Boyle's pairs (γ', γ''), the pair of corresponding values $(p(\gamma'), v(\gamma''))$ belongs to the function c/j or cj^{-1}, since each of those pairs of numbers is of the form $(x, c/x)$ for some x.

If gas samples of different temperatures are admitted, then there are pairs (γ_1', γ_1'') and (γ_2', γ_2'') of simultaneous observations of the same sample for which $p(\gamma_1') = p(\gamma_2')$ and yet $v(\gamma_1'') \neq v(\gamma_2'')$. This fact is expressed by saying that, without the restriction to gas of the same temperature, the volume is not a function of the pressure.

To physicists, the traditional pairing of acts of observation that are simultaneously directed to the same object has become second nature. But if the domains, A and B, of two variable quantities, u and w, are two classes whatever (not just classes of acts of observation), then no particular pairing of elements of A and B is traditional or natural. Yet, only relative to such a class of pairs (α, β), where α belongs to A and β to B, can the question as to whether w is a function of u be formulated. Such a class of pairs[3] must be given. If for each pair (α, β) of that class the pair of

[3] More precisely, a one-to-one correspondence between a part of A and a part of B.

numerical values $(u(\alpha), w(\beta))$ belongs to the function c/j or *log* or f—that is to say, if $w(\beta) = c/u(\alpha)$ or $w(\beta) = log\ u(\alpha)$ or $w(\beta) = f(u(\alpha))$—then we say that, relative to the given pairing, $w = c/u$ or $w = log\ u$ or $w = f(u)$, respectively.

V. *A Notation That Simulates Non-Existent, and Conceals Existent, Analogies*

The formula $v(\gamma'') = c/p(\gamma')$, for any act γ' of manometric observation (and the simultaneous act γ'' of volumetric observation of the same sample) is analogous to the formula $sec\ x = 1/cos\ x$ for any $x \neq \pm \pi/2, \cdots$. The meaning of the formulae is not changed if we let α (instead of γ') stand for any act of manometric observation, and a (instead of x) for any number $\neq \pm \pi/2, \cdots$. The formula $v = c/p$ relates the v.q.'s themselves without any reference to their values or, in fact, to any arbitrary element of their domains. It thus is analogous to the formula $sec = 1/cos$ relating the functions themselves without any reference to their values. It appears that it is the first half of (4) and the somewhat unusual formulae (3), and not the second half of (4) and the traditional formulae (2), that follow the pattern of the laws of physical science, such as Boyle's law, $v = c/p$.

While the traditional notation conceals this analogy, on the other hand, a comparison of the symbols *sin* x and f(x) with the traditional symbols, $v(p)$ and $w(u)$, for the functions connecting v with p, and w with u, strongly suggests 1) that v and w are of the nature of *sin* and f; 2) that p and u are of the nature of x. In reality, however, v and w are physical v.q.'s, and not functions, whereas *sin* and f are functions; and p and v are physical v.q.'s, and not numerical variables, whereas x is a numerical variable. Thus neither of the suggested analogies is valid.

VI. *The Confusion of Derivatives and Differential Quotients*

If f is a well-behaved function, Df is another function; e.g., *sin* and *log* have the derivatives *cos* and j^{-1}. If a variable quantity w is a function of a variable quantity u, then usually another v.q. exists, called the rate of change of w with u, which we will denote by the differential quotient dw/du. For instance, the work, W, done in the course of an isothermic compression of a unit volume of gas, is a function of the volume, v, at the end of the process. The rate of change of W with respect to v is a v.q. which turns out to be equal to the pressure p; that is to say, $dW/dv = p$. Any such relation connects three v.q.'s, whereas any formula such as D $log = j^{-1}$ connects two functions. The statement, found in most treatises on calculus, that "derivatives" and "differential quotients" are synonymous terms is thus at variance with the fact that $2 \neq 3$.

The truth is that if a first v.q. is connected with a second v.q. by a function, the rate of change of the first with respect to the second v.q. is a third v.q. connected with the second by the derivative of that function which connects the first v.q. with the second; in symbols, if $w = f(u)$, then $dw/du = Df(u)$. For instance, the work W done in the isothermic compression turns out to be connected with the volume v by $W = c\ log\ v$. Hence $dW/dv = c/v$ which, by Boyle's law, indeed equals p.

The development[4] of the ideas here presented includes a systematization of the differential as well as the integral calculus, the application of integrals to science, and a theory of functions of several variables.

[4] Cf. the author's "Calculus. A Modern Approach," 2nd ed., Chicago 1953 and the forthcoming book "A New Approach to Mathematical Analysis and Its Applications to Physical Science," Chicago 1955.

The Shortage of Technical Personnel

By W. J. MORELAND

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There is no reason to doubt that the shortage of technical personnel is posing a severe problem for both military and civilian industries—and one that bids fair to continue for several years. But there is reason to believe that the problem itself has not been adequately studied either by industry or by the universities. Even the phrase "shortage of engineers" is so broad as to convey little or no usable meaning. There are research engineers, design engineers, production engineers, etc.; but above all, there is the great range in the degrees of ability of the individuals within each of these categories. Actually, there is probably a greater handicap caused by the misalignment of the men and positions that do exist than that brought about by a shortage of technical people.

It is a curious fact that the selection of manpower to fill vacancies in the sports categories is more scientific and accurate than the selection of manpower for technical positions. For example, a baseball executive never complains that there is a shortage of baseball players. He may complain that there is a shortage of pitchers, but by this he would assume that it is understood that the reference is to twenty-game winners—not just ball players. He is aware of the existence of a sizeable pool of ambitious youngsters anxious to make their mark in the profession. But for him, quality is the important factor—not the total number. Of course, these statements are equally applicable to the problem of the engineering executive. But there is one important difference—in this case there is no simple and accurate measure of the aptitude of the student nor of the proficiency of the graduate. This is especially true in the fields of research and engineering development. Men of mature business judgment will accept the label "graduate engineer" as being a measure of the contents of the package. This, of course, is not the fault of the schools. No reputable institution of learning pretends that the number of years a man remains in school, or the label placed upon him, or even the grades he may earn, is a measure of his ability to achieve success in the technical fields. In fact, the responsibility rests mostly with industry. By offering premiums for labels, they have unwittingly spurred on an increasing number of those poorly fitted to earn these labels. It is the function of the schools and colleges to recognize and cultivate the scientific attitude in its students. But this is an expensive process. It is not being accomplished by today's mass production methods. The schools are aware of this fact but unless more money is made available they cannot hope to supply industry with the people they, in turn, cannot afford to do without.

Sanctuary For Incompetence

A close examination of almost any research organization would reveal a misuse of manpower and a waste of funds. It might seem that such a situation would be a simple matter to discover and correct, but this is not always so. A manager of a development organization of an aircraft company employing several thousand engineers stated that even after six

months employment, it would still be nearly impossible to evaluate the true potential of an individual. No one can pretend to be a ball player, but, unfortunately, it is possible—often unwittingly—to masquerade as a research scientist and perhaps no area in the technical field offers greater sanctuary for incompetence than does research.

At first this may seem paradoxical because of the inherent difficulty of the subject matter and the unquestioned excellence of the people who are leaders in this profession. In the area of research that may reasonably be described as basic, perhaps only 10% of the total effort leads directly to a positive successful conclusion. Nine-tenths of the effort, although perhaps conducted on an equally high level, yields negative results. In one sense this is not wasted effort since it has at least resolved the question of the need for exploration in the particular area. However, it is difficult to distinguish in many cases between incompetence and inherent impossibility of the solution.

A fast growing group of those not well fitted for the task of research is made up of people, usually with excellent academic background, who have become so engrossed in the tools of their trade that they have lost all contact with reality. In this group we might find one who, describing himself as an applied mathematician, could prove, for example, that a bicycle cannot be ridden. When called to his attention that experience was contrary to his conclusion, he is not the least impressed. It is only the beauty and symmetry of his symbolism that is important. He has taken flight from reality. He is a scientific schizophrenic, happy in the world of his own making. Sometimes, in defense of these people, examples are recalled from history which show that great benefits were derived from the apparently aimless meanderings of some earlier genius. This is true. But research is a luxury and it must be purchased with great care. It would be no more logical for an organization to invest a large proportion of its funds in research because of the possibility of great returns than it would for a business man to invest most of his funds in a sweepstakes race merely because it has paid the highest returns on a given investment.

Complicating the problem still further is the existence of another group who have learned that the actions and sounds of competent research people can be readily imitated. They propound ideas and write papers that serve mainly to distract their more competent associates from more useful pursuits. This is strikingly analogous to the example of two locomotives hauling a train of cars. One locomotive may be completely inoperative yet it will look exactly like its mate and perhaps even make the same noises; yet it is riding dead-head, contributing nothing to the effort. It is really impossible from a superficial examination to determine which one is genuine in either case. An erroneous statement made most casually by one such individual may occupy hours of time to disprove. It is a real tribute to the technical stability of this country that it has been able to survive the avalanche of pseudo-scientific papers and reports inspired in many cases by the somewhat frantic efforts of the colleges to maintain favorable publicity ratings.

It would seem to be one function of education to help reduce the magnitude of this problem of misfits by improved selection and training of its recruits. But some phases of modern methods of education are themselves both overly expensive and wasteful. For example, at one engineering school an attempt was made to devise a measure of the efficiency of a lecture. This consisted in defining the efficiency of a lecture as the ratio of the number of man-minutes during which new information was given to the student (which he could not have obtained on his own initiative) to the total number of man-minutes involved during the lecture. Estimates of the efficiency to be expected ranged as high as 75% but the actual results did not exceed 1% for the cases tested.

Suggested Remedy

A suggested remedy for this situation is the elimination of lectures. The teacher could then be used as a consultant to the student but only when the latter needs help and is able *clearly* to state his problem. This is a most revealing method of appraising the student's ability and establishing an atmosphere most favorable for the transmission of ideas from teacher to student. Implied in this approach is the employment of dedicated teachers and few students per teacher. This is expensive. But the added costs would be returned many times in the overall economy. Everyone agrees that in the face of the evergrowing complexity of today's technical problems that industry's pressing need is for greater technical competence. The attempt to supply this need by graduating greater numbers of what must statistically be poorer average quality is even now pressing industry hard. For example, the successful accomplishment of the design, construction and testing of an intercontinental bomber involves the expenditure of many millions of dollars and the best efforts of several thousands of technical people. A director of research at a large aircraft company has stated that he could afford to pay ten times the salary to those who could proceed along beaten paths under their own power until a job was completed as compared to men who required constant supervision in their work; but to the rare individual who could proceed along untried paths with maturity of judgment and persistence of effort to a worthwhile goal, he could afford to pay ten times as much again. Max Börne, the famous German psychologist, has said that in a group of one million men, only one thousand could be described as having done some thinking which leads to logical conclusions, and of this latter group, only one will do original thinking. These examples may be exaggerated, nevertheless, they serve the useful purpose of bringing out in the open a problem that must be faced.

Most everyone is born with some semblance of a research instinct. This is apparent in the relentless questioning with which children approach any new ideas. Unfortunately, some have learned to stifle this instinct so well that long before their college training is over they will accept almost any high-sounding statement or written document without question. A direct result of this unhappy situation is the development of the single characteristic that is fatal to the attainment of the research attitude; namely, a class of individual "who doesn't know that he doesn't know." They have so stifled the still small voice of the questioning instinct that they are able to read a technical statement without being aware that it is not understood by them. Education, which should have the function of cultivating the scientific attitude, often serves instead, like the overwatering of a plant, to anesthetize this instinct.

Mass Production Methods

No one expects the schools to *create* mental giants. All that can be done is recognition, encouragement and some moderate exercising of the important characteristics. In practice, however, our colleges are more concerned with the mass production methods and the setting up of artificial hurdles which, although having some value, can never justify total abandonment of a more logical approach. Not infrequently the student comes away with a sense of accomplishment because of the truly formidable ta[illegible]hich he has been required to perform [illegible]as four to seven years of schooling. Because of this he has mistaken the training routine for the actual battle and when he enters industry it is sometimes a shock to him to find that he is now only at the beginning; that he has picked up a few shiny tools (some of which may be beginning to rust) and that now he must learn the trade. This is the complaint most frequently raised by industry today. This disagreeable situation could be avoided if these facts were to be kept constantly before the student during his training period. Sometimes the argument is advanced that if a school

were to recognize and adopt this completely intellectually honest course, it could not possibly survive in today's strongly competitive atmosphere. But this is merely an abused cliché. There is no evidence to the contrary that with sufficient courage and money, an effort in education that would be a whole order of magnitude better could be accomplished. The following items are suggested as a basis for discussion:

1. Following a common freshman year the distinction should be clearly made between those who wish to follow a truly technical career and those whose concern will be chiefly with man-made problems. No effort should be made to attract men to the advanced technical field by so called "inspirational" talks, financial reward, etc. Rather, the student should be given factual unvarnished information about his chosen field and the true purpose of the training he is receiving.

2. During the second and third years the course content should be common to all the technical students and with no options permitted. The amount of material covered should be reduced to one-half that which it is now pretended to teach and replaced by rigor, thoroughness, and drill in semantics.

3. For the fourth year the student should be permitted to select an *area* of interest but no options within that area.

4. The student would be given the right to earn the degree of research engineer but only *after* completion of a specified time in industry. During this critical period a special effort must be maintained to obtain a measure of his ability. With the maturity of judgment that it is assumed he has now attained, the student should be permitted to select options for his post-graduate work.

Such a program as outlined here, if followed according to the spirit intended, rather than giving mere lip service to it, would be costly and difficult to administer. Whether it is worth the effort should be measured against the contribution it can make toward maintaining economic and military leadership for this country.

Hundreds of men are interviewed daily for positions in the technical field. The process is little more than a ritual. The individual's own opinion of himself, and even his references are notoriously inaccurate technically. Nevertheless, people do get hired and jobs get done. But this may not be enough in an age wherein a few dozen men may solve the problem of pinpointing a hundred of our cities with powerfully destructive guided missiles from a distance of 5000 miles. The men we pick to compete in this contest of high stakes must be the top dozens. Only a few misfits and the results could be fatal. The same reasoning applies, only with lesser force, in our commercial economy. As technical advances become more profound and fewer men are involved, it becomes proportionately more important that those selected be really qualified. Offering high salaries is no easy out since it merely invites competition between the man of words and the man of deeds in a contest whose rules, as most commonly applied, favor the former. Like, for example, picking the best mile runners by insisting they swim the distance.

Characteristic Qualities

Qualities characteristic of successful research people are (1) intellectual courage; a kind of boldness in thinking but not recklessness; (2) the peculiar ability for sustained mental concentration; in effect, mental experimentation. This factor is not entirely subordinate to the will, hence, cannot be demonstrated at will. It responds under favorable environment and gains momentum after mental probing reveals a likely path of attack on a problem; (3) the ability to translate the essential factors of a physical phenomenon into mathematical language. This must not be confused with skill in mathematical manipulation. Mathematics is only a tool. The mental process of the scientist may be likened to the coarse adjustment of a microscope. It feels its way probing a whole area for study, while the mathematical tool, like the microscope vernier,

serves to sharpen the field of view. There is little more reason to assume that a mathematician should have this ability than to assume that a chauffeur could design an automobile; (4) the ability—most difficult to achieve—to maintain a proper balance of effort between the several phases of a project. For example, when theory leads to an impasse, then an appeal is made to experiment and vice versa. Knowing when to advance, and when to retreat from an untenable position, husbanding resources and maintaining interest until a useful conclusion is reached is a most valuable asset. None of these qualities can be revealed by superficial tests or interviews.

The solution of the problem of assigning men to the research job for which they may be best suited holds so much promise of reward that time and effort would be well spent on its study. Two steps are suggested: (a) the accumulation of accurate descriptions of the achievements of the individual insofar as they pertain to qualities similar to those outlined above—not daily activity reports; (b) the evaluation of these records by competent and interested leaders. To be successful, such a program must have the full cooperation and sympathy of the individual. He should be prepared by preliminary indoctrination for the unnatural procedure of attempting to be completely frank and unbiased in his judgment of himself. To help bring this situation about he must be shown that he stands to gain both in mental satisfaction and standing in his profession by his cooperation in the program.

As remarked at the beginning, there is a shortage of engineers; but, as engineering executives know, the talent that is available is our most ineffectively used resource. Here is a promising field of study which can yield important returns to the security and economy of this country.

Graduation, Hold-Back, and Withdrawal Rates in Engineering Colleges

By A. PEMBERTON JOHNSON *

Project Director, Engineering Tests, Educational Testing Service

Introduction

Recently graduation, hold-back and withdrawal rates were compiled and analyzed for over 13,000 fall-of-1948 freshman entrants to 101 engineering colleges. The complete findings of this study, carried out for the U. S. Coast Guard by Educational Testing Service (ETS), Princeton, New Jersey, were reported during May 1953 to the participating engineering colleges by Headquarters, U. S. Coast Guard in an ETS Statistical Report entitled, *Four Year Follow-Up Study of 1948 Freshman Entrants to Engineering Colleges.* This report is now out-of-print. A brief summary of its findings was reported by Dr. Henry H. Armsby in the November 1953 issue of *Higher Education* (published by the U. S. Department of Health, Education, and Welfare) under the title, *Graduation and Withdrawal Ratios.* The present article is intended to provide a summary of this study's findings for those engineering educators who have not seen the earlier publications, and to provide certain interesting comparison data.

Origin of the Study

The program of the U. S. Coast Guard Academy (accredited by ECPD as an engineering-general curriculum) is under constant study by an Advisory Committee of non-service personnel. To provide a factual basis for answering congressional questions regarding the attrition rate at the Coast Guard Academy, the Advisory Committee inquired carefully about recently published data in comparable civilian engineering schools. Finding data of this kind to be completely lacking (and knowing that such a study would be helpful not only to the Congress, the Coast Guard Headquarters, the Advisory Committee, and to the Coast Guard Academy but to engineering education generally), The Commandant, U. S. Coast Guard arranged that the study be undertaken.

Outline of the Study

This is a study of the graduation, hold-back, withdrawal or drop-out of *individual* students. It deals with the first post-war entering class to be primarily non-veterans [1] and is limited to *male non-vet-*

* The author acknowledges with deep gratitude his debt to the following persons whose efforts made possible this article and the study upon which it is based: (1) The Commandant, U. S. Coast Guard, and Dr. Joseph W. Barker, Chairman of the Advisory Committee of the U. S. Coast Guard Academy; (2) The engineering administrators, the registrars and their staffs who painstakingly compiled the data for their institutions; and (3) The ETS staff, particularly Dr. Marjorie Olsen and Dr. William B. Schrader. Professor Bronwell's kindness in suggesting this article is greatly appreciated, as is Dr. Armsby's kindness in allowing this author to quote liberally from his November 1953 *Higher Education* article.

[1] The February 1949 JOURNAL OF ENGINEERING EDUCATION shows 47,426 male students and 14,900 male veterans enrolled as freshmen in U. S. engineering schools and undergraduate extension centers as of November 1, 1948. The proportion of non-veterans is therefore 47,426 – 14,900 divided by 47,426 or 68.6%.

erans. It does not include students enrolled in cooperative programs which alternate periods of college study and industrial work. It includes no transfer students. In the fall of 1952, each of 185 undergraduate engineering colleges (substantially all U. S. engineering colleges) were asked to complete a carefully pre-tested questionnaire. This form requested summary *four year follow-up data* through July 15, 1952 for all male non-veteran engineering college freshmen who had entered each institution in the fall of 1948, prior to November 1.

By mid-winter 1953, 101 engineering colleges had furnished virtually complete and usable data for over 13,000 entrants. These data enabled classification of institutions and their graduation, hold-back and withdrawal rates by size, institutional type, and geographical region. On these three bases, the 101 institutions provide a good, though not perfect, cross-section of United States engineering colleges. It is difficult to know in what respect and to what degree the findings of this report might differ, if data had been included for those institutions which did not return a completed questionnaire.

The Principal Findings

For the 101 colleges, the principal findings are:

1. *One-third* (i.e., 33% of the entrants graduated in four years from engineering or had completed satisfactorily four years of a five-year program of study.

2. 11% of the entrants were still enrolled. (It is estimated that most of these graduated by June 1953.)

3. More than *one-half* (i.e., 56%) had withdrawn or been dropped from engineering during the four years. Of their entrants who withdrew or were dropped, the colleges reported that nearly half were failing or had failed academically, but that two out of every five had withdrawn in good academic standing. In this connection may be quoted a reply by one college official to the request for data: "A large number of students who either are dropped from engineering or who find the program too rigorous are permitted to transfer to our Liberal Arts College or our School of Business, and many of them are accordingly salvaged and receive college degrees in these other areas."

4. Almost *half* (i.e., 46%) of entrants to *privately-supported* colleges graduated in engineering at the end of four years, while only one-fourth (i.e., 25%) of entrants to *publicly supported* colleges graduated in engineering in four years.

5. About *two-fifths* (i.e., 41%) of entrants to *technological institutions* graduated in engineering in four years, while over *one-fourth* (i.e., 27%) of entrants to universities graduated in engineering in four years.

6. Graduation rates differ geographically. In the South Central States (Arkansas, Louisiana, New Mexico, Oklahoma, Texas) less than one-fifth (i.e., 18%) of the entrants graduated in four years while about one-half (i.e., 47%) of entrants in the Northeast States (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, and New York, except Metropolitan New York City) graduated in four years.

7. Graduation rates among the 50 largest engineering colleges reporting data on 100 or more entrants differ more widely between colleges (ranging from 62% to 9%) than between regions or between institutions of different types or of different numbers of male non-veteran entrants.

Comparisons with Other Disciplines

The most recent comprehensive study of graduation and withdrawal rates for individual students in several disciplines appears to be that reported by the Office of Education in Bulletin 1937, No. 11, *College Student Mortality.* In referring to this in his November 1953 *Higher Education article,* Dr. Armsby states:

> The Office study covered students who entered college during the academic year 1931–32 in a group of 25 cooperating institutions. It included 2,547 students in 16 engineering colleges. . . . The 1937 bulletin reported 30 percent of engineering students graduated in 4 years and 62 percent dropped or with-

drawn. Corresponding figures for other disciplines were: Arts and science, 29 percent and 67 percent; commerce and business, 24 percent and 67 percent; home economics, 31 percent and 65 percent; agriculture, 34 percent and 60 percent; and education, 42 percent and 53 percent.

In his discussion Dr. Armsby says:

The statement is often made that the "student mortality" in engineering schools is unduly high, generally with at least an implication that it is much higher than in other disciplines. The earlier study mentioned above indicated that for the class of 1935 the mortality rate was lower in engineering than in 3 of the other 5 disciplines studied, and lower than the weighted average of the 6 disciplines covered. The ETS study shows a lower mortality rate for engineering students for the class of 1952 than for the class of 1935. Unfortunately comparable figures for the other disciplines are not available, but it seems likely that the engineering schools are graduating at least as many of their entering students in 4 years as are schools in most other disciplines to which students are admitted upon graduation from high school.

It is practically certain that improved programs of selection and counseling in junior and senior high schools and in colleges and universities, better teaching at all levels, and more ample financial assistance for needy students, could materially reduce "student mortality" in *all* disciplines.

Comparison with Earlier Studies

Although the differences below may largely reflect chance variations, the findings of this study are slightly more favorable than the findings of two earlier studies: (1) that of the Office of Education for 1931 entrants; and (2) that of the Wickenden *Report of the Investigation of Engineering Education 1923–1929* [2] for the classes of 1923 and 1924.

Classes entering in the fall of	4-year graduation rate (%)	4-year hold-back rate (%)	4-year withdrawal rate (%)
1919–1920	28	10.4	61.6
1931	30	8.0	62.0
1948	33	11.0	56.0

Findings for Hold-backs

Of those who were then enrolled but did not graduate in four years, 62% were reported to have been held back because of academic deficiency, 4% for illness and the remainder (34%) for other unspecified reasons. Colleges with 300 or more non-veteran entrants, private technological institutions, colleges of arts and sciences and colleges in the Northeast reported distinctly higher than average percentages of non-graduates held back for academic deficiency. Colleges in the West North Central states (Colorado, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wyoming) and Western states (Arizona, California, Idaho, Montana, Nevada, Oregon, Utah, and Washington) reported distinctly lower than average percentages of non-graduates held back for academic reasons.

Remarks made on the questionnaires suggest that the principal reason for hold-back may often be hard to determine, and that therefore the reported reasons may not dependably reflect the actual reasons.

Findings for Withdrawals

Among the 50 largest engineering institutions the percentage of students who had withdrawn or been dropped ranged from 29 per cent to 75 per cent. Averages, weighted according to numbers of students were: all 101 engineering colleges in the study, 56 per cent; 53 colleges in universities, 60 per cent; 30 separate engineering colleges, 48 per cent; 50 public institutions, 62 per cent; 33 private institutions, 45 per cent.

An appreciable proportion of the graduates of the 50 largest institutions had experienced academic difficulties: 26 per cent of them had at some time repeated

[2] Volume I, p. 200, of Two Volumes, published by the Society for the Promotion of Engineering Education in 1930 (Vol. I) and 1934 (Vol. II).

one or more courses, 11 per cent had attended one or more summer sessions, and 12 per cent had been on probation for one or more terms. Here again there were wide variations among individual institutions, reflecting, in part, ways of defining and categorizing academic difficulties, and of record-keeping. The percentage of graduates of the 50 largest colleges who had repeated one or more courses ranged from 0 to 71 per cent. Those who had attended one or more summer sessions ranged from 0 to 56 per cent, while those who had been on probation for one or more terms ranged from 0 to 33 per cent.

More than half (57%) of all withdrawals occurred during or by the end of the first year of college, the figures being 27 per cent during the first year and 30 per cent at the end of the year. The withdrawals during or at the end of the second year amounted to 28 per cent of all withdrawals, during or at the end of the third year 11 per cent, and during the fourth year 4 per cent. Considering the withdrawals in terms of percentages of entrants shows that 32 per cent of all freshman entrants were dropped or withdrew by the end of the first year, an additional 16 per cent during or at the end of the second year, another 6 per cent during or at the end of the third year, and 2 per cent during the fourth year—a total of 56 per cent.

Of those who withdrew or were dropped 25.4 per cent were dropped by the college, and 21.5 per cent withdrew voluntarily, but "in failure standing." However, the study contains a note of caution concerning the distribution of withdrawals and the distinction between failing and good standing. Considerable variation was found in the reporting practice in different institutions, and 12.1 per cent of all withdrawals were reported as either "other reasons" or "unknown standing." It was pointed out by many of the colleges that it was difficult for the college to know the reasons for many of the withdrawals.

Of all voluntary withdrawals from engineering: nearly one-half (46%) were made to effect changes in curriculums, and of these more than half (28% of all withdrawals) were students in good academic standing. Only 7 per cent were reported as having withdrawn for financial or family reasons and only 6 per cent because of dislike of engineering. The remaining 41 per cent of the voluntary withdrawals were for various reasons, including military service, transfers to engineering in other institutions, and academic difficulties.

Reasons for the Variations Found

This study did not attempt to pinpoint the reasons for the wide variations in graduation and withdrawal rates among institutions. Carefully conducted studies by appropriate staff groups of individual institutions might in many instances discover circumstances susceptible of improvement along with other circumstances probably not readily alterable by the institution.

Engineering Education Across the Country*

By DEFOREST L. TRAUTMAN

Department of Engineering, University of California, Los Angeles

In this period of evaluation, stimulated in its concerted form by the American Society for Engineering Education, the author was tempted to look about at the present overall enterprise of engineering education. Fortunately, he was enabled to yield to his temptation [1] and spent a year visiting other colleges in the country. These visits provided opportunity for living with students, sampling classes, speaking with staff and administrators, and reading unpublished literature relative to educational planning. The remarks of this paper are the result of his experience and comprise four overall, composite observations of present practices, trends and problems. From these stem suggestions for stimulating the coherent development of engineering education.

Although the questions posed of the educational enterprise continue to be the same down through the ages, the answers expected of engineering education are now more insistent than ever before. The following statements are made poignant deliberately to arouse interest and thus encourage these hoped-for answers.

Observations

1. ***It appears that the nature of engineering education is almost everywhere the same—training for routine doing.***

This consists of preparing students during a limited period for immediate entrance into a career occupation reasonably well defined according to industry and function. Such preparation can be primarily training, and both curriculum and instruction tend to emphasize the practical. Curricula are oriented toward subject matter, and instruction is dictated by the text book as throttled by the instructor. Problem assignments and laboratory experiences are composed around specific apparatus and established procedures. These practices tend to emphasize routine doing rather than creative knowing, and this doing is restricted to the solution of problems already formulated and/or requiring no decision at their inception or conclusion.

Working objectives depend upon what is deemed important relative to facts, concepts, method and/or disciplines. The specific nature of the educational program found at a given school depends not only on overall goal and objectives but also on the character of the institution, students, staff, and administrative leadership. It is not common to find aggressive educational leadership and a staff working together to achieve a common objective.

The two publicized facets of the modern trend are (a) emphasis on the engineering sciences and mathematics and (b) attention to socio-humanistic studies. The former has given rise to departments of engineering science, and an increased attention to research and graduate study. Some persons believe the essence of engineering to be science and mathematics, and they predict that departments devoted (exclusively) to such are the only ones to survive. Regardless of the emphasis on science, such material is generally viewed as a tool. Engineering art is not emphasized as such but may be

* Presented before the Pacific Southwest section of ASEE, San Jose, California, December 29, 1953, and before the Educational Methods Division, ASEE Annual Meeting, Univ. of Illinois, June 17, 1954.

[1] Through the generosity of the Fund for the Advancement of Education (Ford Foundation).

present in information, application, or (traditional) design courses. Despite the heralded design (or synthesis) hallmark of engineering, the undergraduate program is almost exclusively analysis.

The attention to socio-humanistic studies has been part of the movement toward gaining recognition of engineering as a profession. Although some 15% timewise is devoted to a smorgasbord or an integrated program, no one is prepared to evaluate the outcomes. Such subjects are generally believed by the staff to be necessary despite the overwhelming feeling of the students to the contrary. Very soon after their arrival on campus students acquire (no one knows quite how) the set of stereotyped attitudes which helps stabilize the nature of engineering education stated above. The general public is not informed of any departures, even where extensive ones exist.

2. *Potentialities of the student as a learner or as a creative individual in general are not exploited.*

Of major interest to the educational experimentalist is that students appear to respond to their treatment the same regardless of school. They will generally attempt to do what is assigned regardless of the rigor of approach as judged by standards elsewhere, because they "know no different." Nevertheless, the authoritarian character of the subject matter and of the instruction is such that the student must display the accepted approach to get the accepted answer to standardized types of questions.

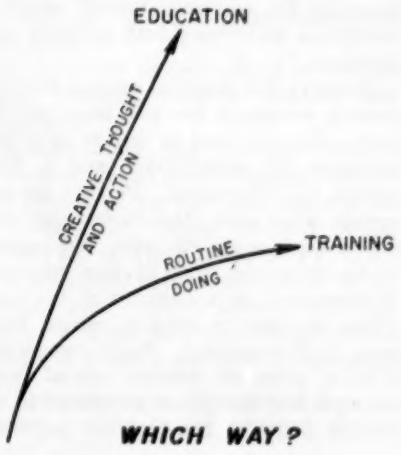
Moreover, the instructor is inclined to rank the difficulty of an approach in terms of how recently (or how well) he has learned it, forgetting that to the student *all* approaches are equally new (e.g., what appears to the teacher as a graduate approach may work wonderfully with sophomores).

Although classes are usually small (under 35) class time is given over primarily to lecture. The emphasis on subject matter coverage minimizes use of recitation and discussion techniques (despite a natural free-time tendency of mankind toward "bullsessions"). Students scarcely have the time to do the required work, and have not the leisure of their colleagues in other departments of the University.

No concerted attention is given the gifted student (or even those above average), as found through Honors Programs in some other college of the University, or through the complete freedom found in some European Science education. Mores are set by a strict grading system.

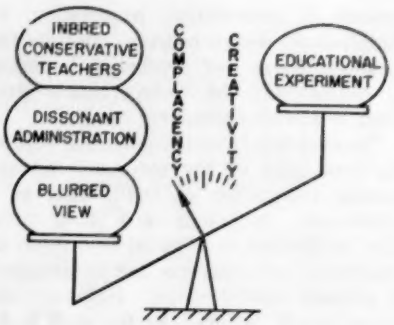
Students select whole curricula, rather than courses, disciplines or teachers. The prevalent subject matter department and option schemes, originally planned (in part) to capitalize on student interests, now find their influence on student motivation waning.

Some schools have recognized these prevalent forces, and have begun to help the student acquire (or at least not lose) a more flexible outlook and to provide him the opportunity of carrying out his desires. In many schools the totality of the activities of the student is thus beginning to receive attention, and advising programs are being established. Consideration is given to the working conditions of the student, his dorm life, his co-



curricular activities, and what *he* actually does in the classroom.

3. *The vigorous evolution of engineering education is hampered by:*
   - *A. Complacent, inbred and conservative teachers,*
   - *B. Dissonant administrative framework, and*
   - *C. A blurred view of the essence of engineering education.*



Complacency results in a lack of desire for change, and is considered the chief enemy of progress. Unfortunately it is rather widespread, prevailing chiefly among those who have lost contact with the profession of engineering, and/or who have found it possible to peddle the same line continuously.

The engineering teacher is also inbred and conservative. Although inbreeding can be the pattern in all vocations (because of the old training the young, etc.), it is certainly true in engineering. Furthermore, the engineering profession today is so rapidly changing that the teaching habits of yesterday are not sufficient for tomorrow. Conservatism stems in part from the nature of the academic system in which the staff is individualistic and in which counsel is sought only from the peers—the resourcefulness of the younger persons is left untapped. Some ten to twenty years later when the younger persons have become peers many of the former ideas—now conservative—will be taken off the shelf.

The administrative framework of many engineering schools is not consonant with satisfaction of student choice and expanding knowledge. Traditional departmentalization, based on training for industry, has produced almost inpenetrable blocks of vested interest, causing departmental rivalries, duplication of course offerings and laboratory facilities, competition in the now evolving common areas of professional activity, and the *accursed* service course. The fact that so many openings for deans of large engineering schools exist for so long a time is partial indication of lack of educational leadership. This condition is unfortunate at a time when engineering education is being reevaluated with such national and local interest. Daring, resourceful, qualified educational leadership is sorely needed.

The key theoretical objective of higher education is generalization of knowledge. This should lead to instruction centered on causing the student to learn concepts (or principles) rather than facts, and such is the result of integration of knowledge. Such integration can proceed on a basis of content or method. The bounds of engineering appear to some to be receding sufficiently to permit further subdivision of programs offered, either on a basis of industry or function. The opposing force is one of unification, that of recasting the emphasis toward essential disciplines underlying both industry and function.

However, the essential essence of engineering education has not been crystallized. This has lead to real or apparent problems of accreditation and a suggestion for bifurcation. Persons are not certain what does characterize engineering or engineering education but appear to be influenced most by new advances in technology or a cleavage of function. (This increase in subject matter leads some to frustration.) Some recognition is being given the relative role of facts, concepts and disciplines as related to education both for function and industry.

4. *Despite the general complacency educational experimentation does exist.*

In each school there are individuals who are trying something different. Often this is the fruit of introspection stimulated nationally by the ASEE and/or locally as a result of administrative changes or industrial pressures.

Each school or department has its own set of working objectives, either explicit or implied, and "activities elsewhere" may thus provide stimulation, suggestion and/or actual data. The following are cited because of their uncommonness, and as evidence of the kinds of departure being effected.[2]

a. Concentration of engineering subjects in the upper division. This stems from the spread of the community college and junior college pattern, the financial necessity to minimize and unify the lower division engineering offerings, and the evolving nature of engineering as an upper division—graduate discipline based on a broad foundation of science, mathematics and socio-humanistic studies.

b. Pre-junior summer engineering camp for all engineers to unify their lower division work. A community survey project helps the student to integrate his prior socio-humanistic and technical knowledge, and also to evolve ideas relative to the role of engineering in modern society—an experience especially of value to students coming to the campus as Juniors.

c. Continual modernization of subject matter content, through research and scholarship.

d. Elementary and advanced sections of same or similar course meeting together —a version of the one-room schoolhouse.

e. Integrated lower division math-physics course (with remarkable results).

f. Interdepartmental disciplines in instrumentation, nuclear science, materials, system analysis and engineering science (where it is not a separate department).

g. Integration of all courses both within and outside engineering around the theme of a common (scientific) methodology. Gives students confidence and power in meeting new situations.

h. High school graduation not required. Good early entrants (after tenth grade) do well in engineering. Other programs also minimize redundancy of 11–14 grades.

i. Student questions "answered" by questions from instructor—guide student to evolution of his own answer and more personal knowledge about the knowing process. Great teacher success also claimed when student is caused to relate the subject matter (whatever it may be) to his own personal problems.

j. Evaluation situations directly related to objectives. Examinations prepared by special group. Take-home exams worked with collaboration—even with instructor. Senior comprehensive in engineering.

k. Acceptable industrial employment required for graduation (usually one summer). Engineering practice school post B.S.

l. No departmental subdivisions; all staff members contribute to and are serviced by the main stockpile of ideas and concepts; students satisfy their specialized wants through technology course selectives in the senior year.

m. Unified laboratory (rather than with separate courses). Knowledge from all courses must be brought to bear on given laboratory situations.

n. Accreditation not sought for four year program.[3]

o. Proceeding via course exams at student pace.

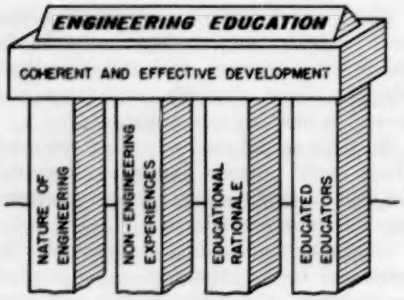
p. Birth of programs such as Pharmaceutical Engineering to prepare engineers for specific industry unattractive to "conventional" engineers (or more demanding).

Suggestions

Consideration of the possible implications of these observations has led the

[2] The author will refer queries from interested readers to the pertinent persons and/or schools.

[3] There exists no strong force toward lengthening of the undergraduate program although no coherent educational analysis has been advanced.



author to propose the following fourfold manner in which the coherent and effective development of engineering education might be stimulated. These are not answers but rather directions in which to pursue answers.

1. *It is important—isn't it?—to understand the nature of engineering when planning programs in engineering education.*

The schools serve the dual purpose of preparing persons both to *practice* the profession and to *lead* the profession. Engineering education is thus both the follower and the forerunner of engineering, and they therefore must evolve together.

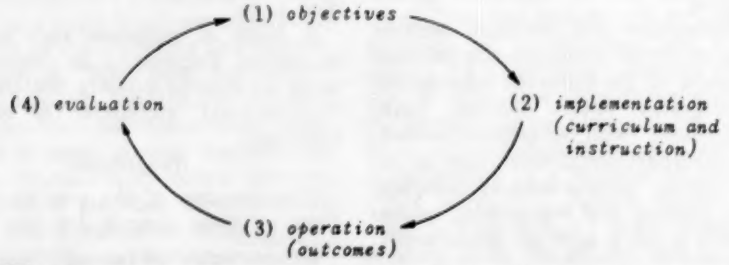
In getting a handhold on the nature of practice and of education it appears profitable to strip off adjective multipliers (by industry or function) and emphasize the key word itself—engineering. Our educational goal is to enable the student to develop the requisite disciplines for a foundation for professional activity in a limited period of time. These, if in the category of thinking, knowing, communicating (etc.), are relatively independent of the subject matter employed. People, however, are not yet agreed as to what the body of engineering knowledge is nor what the fundamental things to be taught are.

2. *Should we not be keenly aware of educational activities outside of engineering?*

The suggestion to look without engineering need not imply that other enterprises are more successful than is engineering education, but rather that through sharing points of view, by contrast, significant points are driven home. We might be interested to observe architecture, medicine and business, and integrated programs in general education.[4] Several non-engineering faculties have already rallied round a cause sufficiently to provide significant data. Much may be gained through thoughtful consideration of the socio-humanistic studies. The author has also found helpful the educational approach of certain industries.

3. *We have excellent examples of a decided element of objectivity in the functioning of successful engineering enterprises.*

Engineering education should be no different from other human endeavors in which the following four facets are effectively related



[4] The Foundation for Integrated Education (New York) purports to be a clearing house for ideas and inspiration.

with a functional relation implied between them, and the last leading back to the first. This scheme permits treatment of problems in education by the same methodology as problems in science, employing a measure of analytics and a measure of experience. In the realm of providing such an educational rationale there exists the possibility of distilling out what might be called a science of education, whether it pertains to curriculum or to instruction. (That portion which appears to be the traditional art can then receive appropriate emphasis.) The rationale would also likely include a discovery of the basic requisite disciplines necessary to the utilization of knowledge.[5] All told, these activities might be grouped under the heading of *Education Engineering.*

4. *A formal educational background is considered practically indispensable to the preparation of future engineers. Might not this concept apply to future educational leaders as well?*

Such definitive attention to the development of our future educational leaders might encompass study in the three areas mentioned above: Nature of engineering, non-engineering experiences and educational rationale. The men produced solely by the enterprise of engineering education tend to be more oriented toward getting the job done than to consideration of longer range philosophical issues. Attention to the latter appears to be a necessary requisite of able educational leadership in a technological society.

[5] Possibly in contrast to the extension of knowledge.

ANNUAL MEETING—1955

Pennsylvania State University

State College, Pa.

June 20-24, 1955

"YETs? What's That?"

By ROBERT T. HOWE

Asst. Prof. of Civil Engineering, University of Cincinnati, and Chairman, 1953–54, Committee on Young Engineering Teachers

The Committee on Young Engineering Teachers has been a part of ASEE for four years. Almost everyone who has attended a Sectional, or National Meeting during this time has heard of the Committee, and many have attended YET sessions at these gatherings. Older members often say they wish that YETs had been in existence when they were younger. Never-the-less there are Society members, including a great many younger ones, who say "YETs? What's that?". This article will attempt to outline the role of the Committee on Young Engineering Teachers in Society affairs.

History of the Committee

After a year of studying how ASEE might be of greater service to its younger members, and also develop future leadership for its activities, a committee headed by Professor Frank L. Schwarz submitted a report to General Council. This report, published in the April 1950 issue of the JOURNAL OF ENGINEERING EDUCATION, recommended that a Committee on Young Engineering Teachers be formed within the Society, and suggested the following objectives for such a group:

1. An understanding of the general goals and responsibilities of the two professions which every teacher of engineering follows, engineering and education.
2. Orientation into the history, the lore, and the "unwritten laws" of the dual profession of engineering education.
3. An acquaintance with the most effective instructional materials and methods, with methods of evaluating student achievement, and with the elements of counseling and student guidance.
4. Guidance in his personal professional development both as an engineer and as a teacher.
5. A means of exchanging ideas with his contemporaries.
6. Stimulation.
7. Dissemination of knowledge.

Such a Committee was formed during the 1950 Annual Meeting, and it has grown in size and activity yearly since that time.

The suggested objectives, quoted above, have met with widespread approval within the Committee. While they have never been officially adopted, they have been "absorbed" as the goals of YETs. During the past four years YETs have considered two themes based upon these objectives: "Teaching Experience vs. Research vs. Industrial Experience vs. Ph.D. As the Road to Good Teaching," and "The Professional Development of the Young Engineering Teacher." These topics have provoked a great deal of discussion which has helped young teachers to formulate their personal plans for becoming true engineering educators.

The original study committee suggested that "young" be defined as "not over 36 years of age, and of rank below associate professor." This definition caused the Committee so much embarrassment during the first two years of its existence that at the 1952 Annual Meeting the Committee decided to abandon all formal definitions of "young" in regard to those who might participate in YET activities, but to re-

tain the definition, in so far as possible, in the selection of Committee Officers, and further, that the Chairman should always meet the suggested restrictions.

Purpose of the Committee

A strange paradox exists in regard to reactions to the existence of this Committee. Older members almost unanimously comment on the great value of such an organization and often say, "We wish that there had been such a group when we were younger.", while young teachers often say, "Why should be belong to such a special group? We want to be accepted as full members of the Society!". These two reactions seem to distinguish between those who know why the Committee exists, and those to whom this article is directed.

The Committee on Young Engineering Teachers might be compared to a seed bed into which the Society scatters all kinds of seeds in the form of its new, young members. Each seed has the potential ability to grow into a worthwhile plant, so each young member has the potential to develop into an outstanding teacher, a research scientist, a counselor of students, an administrator, or as a hybrid of two or more of these types. The Society waters and fertilizes this seed bed with encouragement, and moral and material assistance, looking forward to the day when each seed will blossom forth as an engineering educator.

Just as seeds must sprout both roots for stability and leaves, stems, and flowers or fruit for beauty and utility, so the young teacher must grow both in wisdom and in stature. He must send out roots seeking for new knowledge, or new means of communicating knowledge, and he must simultaneously show forth this new knowledge in productive activity. Some seeds try to grow bigger within their own skins and never burst forth into usefulness; others send out inadequate roots so that the bloom which comes quickly also fades quickly; while still others develop extensive root systems, but are gnarled and distorted above the ground. Similarly some young teachers are so concerned with making money that they neither study nor grow in usefulness; others want to be seen and heard but are unwilling to attain the knowledge which makes their actions worthwhile; while still others become so engrossed in acquiring knowledge that they never take time to effectively transmit that knowledge to others.

A seed may be planted and cared for but it cannot be made to sprout, for the power to grow lies within the seed itself. Here men have one advantage over seeds for while each man can develop personally and professionally only as he desires to develop, fellowmen can help and encourage each other in the growth process, if only by inciting competition to attain a desirable goal. Here then is the purpose of the Committee on Young Engineering Teachers; it is an organization directed toward encouraging young engineering teachers to develop into well-rounded engineering educators. As the objectives quoted above indicate, YETs are concerned with helping embryo teachers develop both roots of understanding and stalks of fruitful activity.

Because seeds are often sown too densely in a seed bed the gardener transplants the stronger sprouts to other areas so that they may continue to grow individually while the seedlings left behind have more room in which to show forth their value. As young ASEE members develop on their local campuses they are observed by YET Subchairmen who nominate them for greater responsibilities within the Committee. As the Subchairmen grow in ability they are transplanted into Section, Division, or higher YET Offices by the Society Officers who are observing their work. In this way room is constantly being prepared both for new young members to become active, and for established young leaders to continue to grow in usefulness.

Conclusions

Society members who know of the purpose of this Committee look upon it as a

seed bed. If you are a new, young teacher what kind of a seed are you? What kind of an engineering educator do you hope to become? If you are anxious to grow in usefulness the Committee on Young Engineering Teachers will welcome you into its activities of mutual encouragement and help toward personal and professional growth.

If you want specific information about YETs why not write today to Professor Philip Weinberg, Department of Electrical Engineering, University of Utah, the Chairman of the Committee for 1954–55?

Sections and Branches

After accepting the invitation to hold a fall meeting of the **ASEE–Ohio Section** at the USAFIT, Wright-Patterson Air Force Base, Ohio, a two-day conference was decided upon to permit the visitation of the Base laboratories, the inspection of the physical equipment of the Air Force Institute, and the viewing of the latest aircraft, in addition to the holding of a technical session.

R. A. Seaton, Director, USAFIT, welcomed the visiting delegates to the Wright-Patterson Air Force Base, Ohio. General Swofford, Commandant of the Institute, was away on official orders on an assignment in California.

The first paper presented treated the "Geopolitic Significance of Indo-China and Brazil in Relation to the Rubber Industry." A. L. Freelander, President, Dayton Rubber Company, was well qualified to speak on this topic due to his association of long standing with the rubber industry.

In his paper, "Titanium, Its Current Engineering Status," Lt. Harris M. Burte, Project Engineer, Light-Metals Section, Materials Laboratory, WADC, discussed the processing, the fabrication, and the applications of this light metal in present day practice.

Chairman K. F. Sibila, University of Akron, presided at the 1800 hour dinner meeting, and introduced President N. W. Dougherty, ASEE, University of Tennessee, who addressed the group on the topic of "Engineering Education."

The evening entertainment consisted in the viewing of two base films, the one depicting the life of a stranded plane crew in the tundra of Alaska after a crash landing; the other showed the reactions of the two white mice and the two monkeys as they were subjected to gravitationless status in the rocket that soared 240 miles into outer space above the sands of New Mexico a couple of years ago.

The first part of the second day's program consisted in inspecting the facilities of the Base Technical Institute to impart an engineering education. Exhibits were on display and experimental demonstrations were given in the following departments: Electrical Engineering, Aeronautical Engineering, Mechanical Engineering, Installations Engineering, Mechanics, Physics, and Industrial Administration. The Institute's Library was open for inspection. Military and civilian staff members were in attendance to demonstrate experimental set-ups and to answer questions raised by the visitors.

The conference closed with the tour of the flight lines of Area A and Area B of the base where the latest types of Air Force aircraft could be seen.

A Brief Report on the Salaries of Engineering Teachers Based Upon Data Collected by Engineers Joint Council in 1953

By FREDERICK R. HENDERSON

Associate Professor of Industrial Engineering, Northeastern University

Foreword

In June, 1949, the A.S.E.E. Committee on Faculty Salaries published "A Survey of Teachers' Salaries in Engineering Schools and a Comparison of These with Salaries Paid to Engineers in Non-Teaching Employment and with Teachers' Salaries in Other Professional Schools." Included were data from 123 engineering schools covering salaries of 8541 members of their teaching staffs for the school year 1948–49.

In April, 1953, the Engineers Joint Council, as part of a survey of earnings of engineering graduates, sent, to the deans of all engineering schools, questionnaires to be answered and returned to E.J.C. by individual faculty members. Approximately 3000 of these were returned, and after they were analyzed by E.J.C., these questionnaires were turned over to A.S.E.E. for such further analysis as the Society wished to undertake by way of supplementing the 1949 A.S.E.E. salary survey.

A preliminary study of the E.J.C. questionnaires immediately revealed a substantial variation from the 1949 A.S.E.E. study insofar as the distribution by geographical region and professorial rank was concerned. The Executive Board of A.S.E.E., therefore, concluded that any detailed comparison between the 1949 data and the E.J.C. questionnaires was not feasible. It did appear, however, that some general conclusions as to trends could be drawn, and at the request of the Executive Board, Professor Frederick R. Henderson of Northeastern University agreed to make an abridged study of the E.J.C. questionnaires and to prepare a brief report on the results obtained for the A.S.E.E. Annual Meeting in June, 1954.

Grateful acknowledgment is made to Mr. W. T. Cavanaugh, Assistant Executive Secretary of the Engineering Manpower Commission of E.J.C., for his cooperation in making available the questionnaires upon which this report is based and to Dean Wilfred S. Lake of Northeastern University for his friendly counsel in matters of statistical procedure.

Purpose and Plan of the Report

Introduction

Having examined the salary questionnaires submitted to E.C.J. by engineering faculty members in the spring of 1953 to determine first of all whether or not these constituted a sufficiently representative sample to warrant further statistical analysis, and having reached the conclusion, with certain minor reservations, that the sample was in the main adequate for this purpose, I have endeavored to answer the following questions.

1. What significant changes have occurred in faculty salaries from 1948 to 1952?

2. What was the financial situation of engineering teachers in 1952–53 as compared with their classmates in industry and government?
3. What is the relationship, if any, between the so-called base salary for teaching during the academic year (9–10 months) and the total earned income for the calendar year?

Treatment of the Data

Since the 1949 A.S.E.E. survey reported salaries on a 10-month basis (12-month salaries having been reduced by 1/6), the same basis was adopted for the "basic salary" on the E.J.C. questionnaire, and basic salaries covering 11 or 12 months were reduced 1/6 before tabulating them.

The A.S.E.E. survey included only the four ranks of professor, associate professor, assistant professor, and instructor. It, therefore, seemed wise to disregard E.J.C. questionnaires from deans and from persons engaged wholly on research.

A few questionnaires from areas outside the continental United States were also eliminated since these areas were not included in the previous study.

The A.S.E.E. survey divided the country geographically into seven regions, and the same division was adopted for this study. These regions are as follows:

Region I. Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut
Region II. New York, New Jersey, Pennsylvania, Delaware, Maryland
Region III. Ohio, Indiana, Michigan, Illinois, Wisconsin, Iowa, Minnesota
Region IV. Virginia, District of Columbia, West Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi
Region V. Missouri, Arkansas, Kansas, Oklahoma, Louisiana, Texas (East of Pecos River)
Region VI. California, Nevada, Utah, Arizona, Colorado, New Mexico, Texas (West of Pecos River)
Region VII. Washington, Oregon, Idaho, Montana, Wyoming, North Dakota, South Dakota, Nebraska

Since the basic data in the 1949 A.S.E.E. survey were obtained directly from officials of the 123 engineering schools represented, whereas the 1952 E.J.C. data were obtained from questionnaires sent in directly by the individual faculty members, it was necessary to determine whether or not there were significant differences in the institutions represented in the two surveys. Fortunately more than 90% of the E.J.C. questionnaires included the name of the institution; consequently, it was possible to make this comparison.

After careful analysis, it appeared that in Regions II to VII inclusive, the institutional representation in the two surveys was reasonably comparable. In Region I, however, it appeared that two relatively important institutions were inadequately represented in the E.J.C. survey, and the analysis subsequently made shows that the upper quartile and median salaries for Region I in the E.J.C. survey, which are skewed downward, *are not truly representative of this region.*

Two other factors deserve mention. First, the E.J.C. questionnaire did not provide a space to indicate whether or not the individual was on a full-time or part-time basis. A qualitative study of the data indicates that the great majority of those replying were on a full-time basis. There were an appreciable number of questionnaires, however, which reported a very high total income coupled with a relatively low basic teaching salary. It seems likely that many of these persons were on a part-time basis although not so indicated.

Secondly, there appeared to be some confusion as to what was meant by the question: "How many months did this basic salary cover?" Again speaking qualitatively, it seemed that some persons replying "12 months" were actually on

a 10-month basis but paid in 12 installments.

I do not believe that errors introduced by the above two factors had a significant effect upon the tabulated overall results, but they may well account for some of the minor variations from the anticipated norms.

The questionnaires were sorted by academic rank and geographical region, and the upper quartile, median, and lower quartile for each classification were determined. Tabulations were made for both the ten-months base pay and for the total engineering income.

The data were then re-sorted by academic rank and by year of baccalaureate degree, and quartile tabulations were made for total engineering income within each academic rank.

Finally an overall tabulation of both base salary and total income versus year of graduation was made to provide a comparison with the corresponding tabulations compiled independently by the E.J.C. and presented in their report entitled "Professional Income of Engineers —1953."

Calculations were made of the percentage distribution of questionnaires by rank, region, and year of graduation as an aid in evaluating the reliability of the results of the salary study.

And lastly the ratio of the ten-months' base pay to the total engineering income was calculated for each quartile by rank and region to determine whether or not a significant relationship exists between them.

The results are presented graphically in the body of the report; the detailed tabulations are given in the appendix.

Individual Distribution of Questionnaires

As previously indicated, a qualitative study of the questionnaires revealed that returns from Region I were inadequate to provide a reliable index of salaries in that region. For the country as a whole, however, the E.J.C. regional distribution as shown in Figure 1 appears to be reasonably comparable with that of the 1949 A.S.E.E. survey.

The distribution by academic rank presents quite a different picture. Whereas in 1949, full professors accounted for only 21% of the total, in 1953 this figure had increased to 35%. And whereas instructors in the A.S.E.E. study comprised 39% of the total, in the E.J.C. survey, they number only 12%. This shift in rank distribution is shown in Figure 1. Whether this represents a major up-grading in terms of rank or whether it is an indication that the E.J.C. data are not in fact a representative cross-section of engineering educators, is difficult to determine from the information at hand.

Referring to Figure 2, the age distribution (as indicated by the year of graduation) both overall and within each rank seems to follow a reasonable pattern. The A.S.E.E. survey did not include complete data on age distribution, but the average ages of staff members were estimated to be as follows: professors—49 years, associate professors—44 years, assistant professors—36 years, instructors —30 years. Assuming the median age at year of graduation to be 23 years, the present study (see Fig. 2) gives approximate average ages as follows: professors —49 years, associate professors—39 years, assistant professors—33 years, instructors—28 years. It, therefore, appears that the average age in each rank except full professor is appreciably lower than it was five years ago. This would seem to support the conclusion that there has occurred a substantial up-grading in terms of academic rank during this period and that there actually are fewer engineering teachers with the rank of instructor than there were in 1949.

Furthermore, since the age distribution within each rank as shown in Figure 2 approximates reasonably well the normal bell-shaped curves, it would seem that regardless of the over-all distribution by

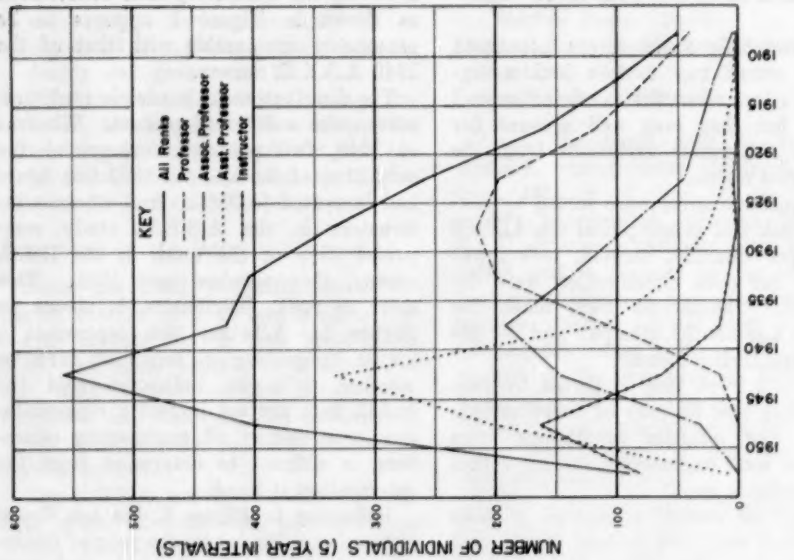


Fig. 2. EJC distribution by year of baccalaureate degree

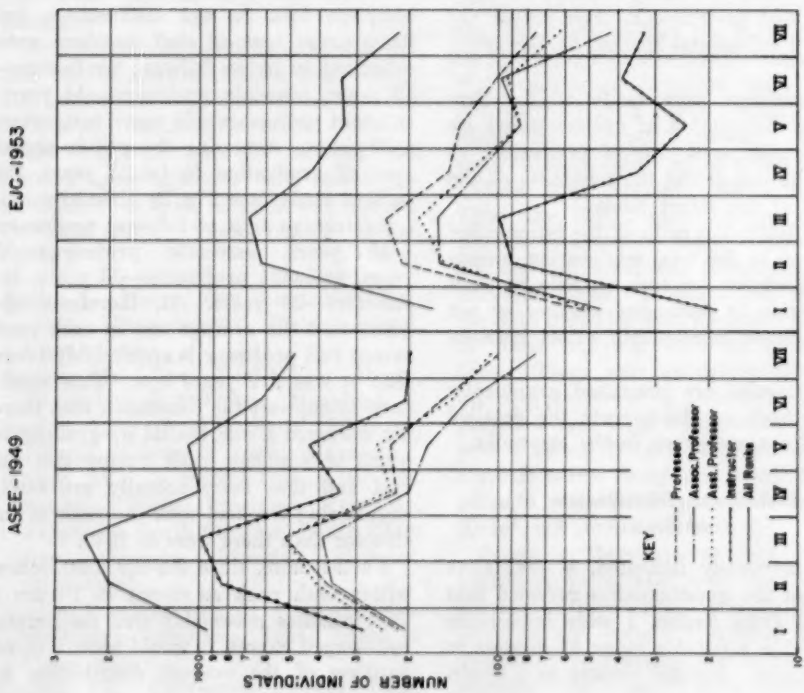


Fig. 1. Academic Rank Distribution—ASEE vs. EJC

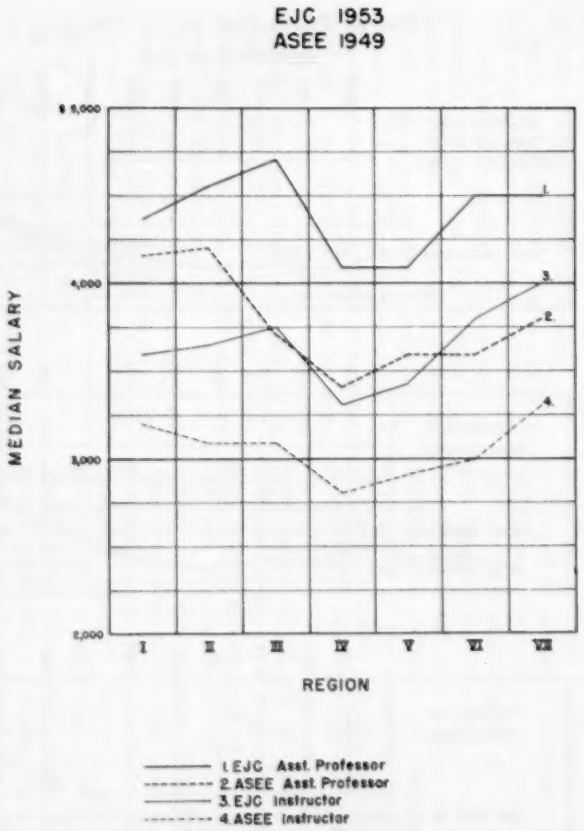


FIG. 3A. Ten-months' base pay—ASEE vs. EJC

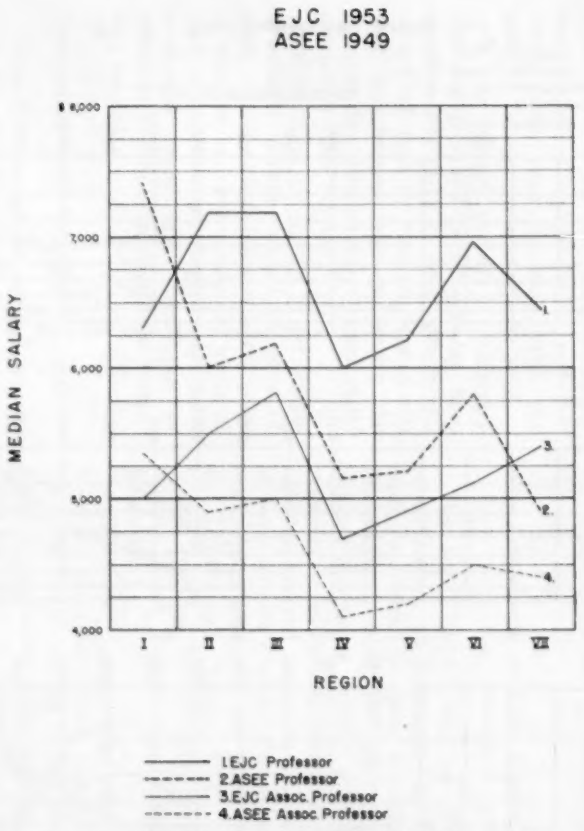


FIG. 3B. Ten-Months' Base Pay—ASEE vs. EJC

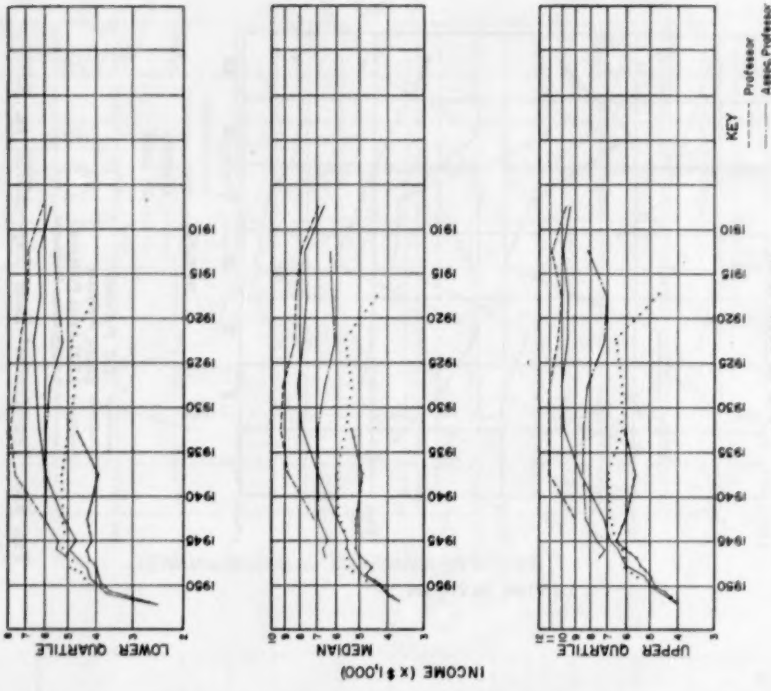


FIG. 5. Total engineering income

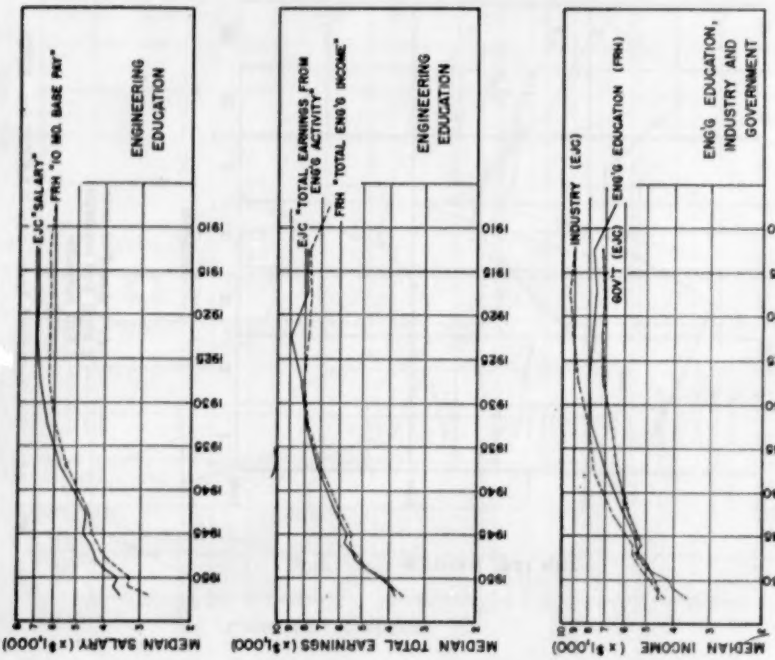


FIG. 4. This study vs. EJC Report

rank, the data for each rank separately are reasonably representative, and that comparisons, rank by rank, with the A.S.E.E. survey are statistically valid.

If our present survey is reasonably representative, and there has in fact been a substantial shift in rank distribution since 1949, rank by rank comparison will tend to minimize increases among the younger men attributable to more rapid promotion than normal.

On the other hand, even if our sample is actually skewed upward in terms of rank, overall comparisons with engineers in industry and government in terms of year of baccalaureate degree seem valid since this overall age distribution as shown in Figure 2 appears to be reasonably normal.

Comparison with 1949 A.S.E.E. Survey

Since the data for the A.S.E.E. survey were obtained from institutions whereas the E.J.C. data were obtained from individuals, it appeared that the only valid comparison which could be made would be that between individual media.

Data on individual media salaries (ten-month base pay) were, therefore, plotted by geographical regions and by academic ranks, and the results are shown in Figures 3. Except for Region I (where we know the data are not representative and are skewed downward) a remarkably consistent pattern is revealed showing a substantial increase in base salary in all ranks and regions. Countrywide this increase amounts to 20% from 1948 to 1952 and compares with an increase of about 13% in the cost of living index * for the same period.

We are all aware that in the years following the close of World War II, the cost of living increased very sharply, and teaching salaries increased relatively slowly. It appears that during the past few years, salaries have continued to rise, and the gap between income and cost of living has been narrowed appreciably.

Comparison with the General E.C.J. Survey

The E.J.C. report entitled "Professional Income of Engineers—1953," recently published, contains a number of tabulations showing the upper quartile, median, and lower quartile salaries for engineers in education, government, and industry arrayed according to the year of baccalaureate degree. Two tables for engineering education are given in the E.J.C. Report: Table XIX covers "Basic Teaching Salary" and Table XX covers "Total Income of Engineering Educators."

Although my tabulations were made from the same basic data, they differed from the E.J.C. results in two respects. First, I eliminated questionnaires from deans and from persons engaged entirely in research. Secondly, I adjusted all basic salaries to the ten-months' basis. It seemed desirable, therefore, to compare these with the E.J.C. tabulations.

A word of caution is perhaps in order at this point concerning the visual comparison of the graphs in the E.C.J. report and those in this report. Inasmuch as entirely different scales were used for plotting both ordinates and abscissae, the appearance of the corresponding graphs in the two reports is quite different. I have tried in this report to plot the data in a way to bring out visually what seem to be significant variations.

Figure 4 shows a comparison of median figures as compiled by E.J.C. with the new computations. It will be observed that the adjusted "Ten-Months' Base Pay" figures (upper chart) are appreciably lower than the E.J.C. "Basic Teaching Salary" figures. The two graphs for "Total Income" (middle chart) agree very closely except for the period 1920–1924. I suspect that there may be a typographical error in the E.J.C. data for that period.

The lower chart on Figure 4 shows a

* Consumers Price Index—Bureau of Labor Statistics.

comparison of total earnings in engineering education versus salaries in industry and government. It is recognized that the latter are perhaps not identical with total engineering income, but common experience would suggest that the differences are no so great as to invalidate a qualitative comparison. This chart bears out the generally accepted opinion that by and large industry pays better than teaching or government service. This chart also suggests that the older educators have fared less well than their younger colleagues, so that a further study of income in relation to age and academic rank has been made.

Figure 5 shows the total engineering income for each professorial rank plotted against the year in which the men received their baccalaureate degrees. This seems to indicate that the younger men have forged ahead of their older associates in all ranks, and the pattern is the same for the upper quartile, median, and lower quartile. Perhaps the economic pressure upon the younger men with growing families in a period of rising prices has been more severe than for the older men whose children are now established on their own.

Relationship Between Base Salary and Total Income

The 1949 A.S.E.E. survey did not attempt to evaluate the relationship between the ten-months' base salary and total income for the year. The importance of this relationship is obvious particularly in making comparisons with salaries paid in industry and government. The E.J.C. questionnaires did, however, furnish data on both base salary and total income, and quartile tabulations of both by rank and region were made as previously indicated. It was, therefore, a simple matter to calculate the ratio of base salary to total income for each quartile in each rank and region. The results were surprisingly consistent throughout, and the median of the medians was found to be 78%.

In order to verify this computation, the median figures for total engineering income were multiplied by 78%, and these values were plotted along with the actual medians for the corresponding ten-months' base salaries. The results clearly indicated close correlations between base pay and total income.

There seems to be no significant variation from the norm among the various academic ranks; the variations in the rank of instructor are attributed to the small size of the sample.

There does seem to be a slight variation regionally. As might be expected, total income is slightly above the norm in Region II where opportunities for consulting work are plentiful, and it is slightly below the norm in Region VII where consulting opportunities are probably less readily available.

The variation in terms of age (or year of graduation) bears out the hypothesis that economic pressure on the younger men has forced them to supplement their salaries to a larger extent than their older colleagues have found necessary.

As an overall yardstick, nevertheless, I believe it is reasonably accurate to conclude that the ten-months' base salary for engineering educators constitutes from 3/4 to 4/5 of the total annual earned income.

Summary

The following general observations seemed warranted from this brief analysis of the questionnaires submitted by engineering educators to E.C.J. in 1953.

Academic Rank

There seems to have been a substantial change in the percentage distribution of engineering teachers in the four academic ranks. Today there appear to be fewer instructors and more full professors than there were in 1949. In order to be sure of this trend, however, it would be necessary to obtain current data comparable to that of the 1949 A.S.E.E. Report.

Teaching Salaries

Salaries in all ranks have generally increased by about 20% in the period from 1948 to 1952. This compares with an increase of about 13% in the cost of living during the same period. Younger faculty members have in general obtained larger percentage increases than their older colleagues.

Engineers in industry continue to command higher salaries than do engineering educators although the differences in total income are perhaps not so large as is commonly supposed.

Basic Salary versus Total Income

In general the basic salary for the academic year of nine to ten months constitutes about 3/4 to 4/5 of the total annual income of engineering educators, this basic salary in most instances being supplemented by income from evening and summer teaching and from consulting work.

APPENDIX A

Analysis by Geographical Regions

Region	I	II	III	IV	V	VI	VII	Total
Individual Distribution—1949 (ASEE)								
Professor	216	376	520	222	232	153	101	1,820
Assoc. Prof.	206	362	387	204	173	127	77	1,536
Asst. Prof.	242	411	517	230	253	143	105	1,901
Instructor	283	845	979	340	432	206	199	3,284
Total	947	1,994	2,403	996	1,090	629	482	8,541
Individual Distribution—1953 (EJC)								
Professor	52	213	241	148	137	104	77	972
Assoc. Prof.	46	158	163	116	86	99	43	711
Asst. Prof.	50	155	186	128	85	94	64	762
Instructor	19	88	99	35	24	39	33	337
Total	167	614	689	427	332	336	217	2,782
Ten-Months Base Salary 1952–1953 (EJC)								
Professor								
Upper Quart.	7,340	8,000	8,300	6,500	7,000	8,300	7,450	
Median	6,300	7,200	7,200	6,000	6,230	6,950	6,450	
Lower Quart.	5,450	6,200	6,400	5,400	5,700	6,100	6,000	
Assoc. Prof.								
Upper Quar.	5,940	6,000	6,300	5,100	5,400	6,000	6,090	
Median	5,000	5,500	5,800	4,700	4,900	6,100	5,400	
Lower Quar.	4,600	5,000	5,020	4,400	4,580	4,700	5,000	
Asst. Prof.								
Upper Quar.	4,890	5,000	5,100	4,450	4,400	5,000	4,900	
Median	4,370	4,550	4,720	4,100	4,100	4,500	4,500	
Lower Quar.	3,900	4,200	4,200	3,750	3,800	4,090	4,200	
Instructor								
Upper Quar.	4,020	4,000	4,150	3,600	3,700	4,100	4,230	
Median	3,600	3,650	3,750	3,300	3,380	3,780	4,000	
Lower Quar.	3,300	3,250	3,500	3,000	3,000	3,480	3,710	
Total Engineering Income—1952 (EJC)								
Professor								
Upper Quar.	11,000	12,000	11,900	9,000	9,400	10,700	9,050	10,750
Median	8,050	10,000	9,600	7,700	8,000	8,550	8,000	8,680
Lower Quar.	6,640	8,200	7,840	6,640	6,850	7,300	7,100	7,280
Assoc. Prof.								
Upper Quar.	7,200	9,000	8,800	6,950	7,400	7,870	7,770	8,000
Median	6,450	7,480	7,170	6,170	6,570	6,850	6,800	6,800
Lower Quar.	5,800	6,250	6,300	5,380	5,800	5,810	5,400	5,880
Asst. Prof.								
Upper Quar.	6,000	7,500	6,800	6,000	5,770	7,000	6,340	6,500
Median	5,280	6,000	5,850	5,370	5,080	5,990	5,560	5,650
Lower Quar.	4,950	5,300	5,300	4,700	4,480	5,000	5,000	5,000
Instructor								
Upper Quar.	4,980	5,550	5,500	5,400	5,200	5,600	5,300	5,410
Median	4,400	4,720	4,660	4,500	4,810	4,800	4,800	4,700
Lower Quar.	3,700	4,000	4,000	3,500	3,720	4,000	4,100	4,000

APPENDIX B

Analysis by Year of Baccalaureate Degree

Year of Degree.....	1952	1951	1950	1949	1948	1947	1946	1945	1940–1944	1935–1939	1930–1934	1925–1929	1920–1924	1915–1919	1910–1914	1909 & earlier	Total
Individual Distribution—1953 (E.J.C.)																	
Professor						1	1		15	105	201	216	198	119	76	40	972
Associate Professor		1	1	2	4	10	8	10	148	192	140	93	45	32	21	4	711
Assistant Professor		1	7	18	56	68	33	30	331	110	54	26	12	10	4	2	762
Instructor	13	16	50	54	40	34	12	21	64	16	10	1	3	1	0	1	337
Total	13	18	58	74	100	113	54	61	558	423	405	336	258	162	101	48	2782
Ten-Months Base Salary —1952–53 (E.J.C.)																	
All Ranks																	
Upper Quartile	3450	3900	3700	4000	4200	4500	4750	4700	5050	6200	7000	7500	7330	7200	7500	7370	
Median	2800	3400	3370	3630	3900	4100	4220	4400	4550	5400	6000	6270	6240	6200	6250	5950	
Lower Quartile	2100	3000	3100	3300	3600	3770	3800	3820	4100	4700	5000	5150	5400	5230	5130	4700	
Total Engineering Income —1952 (E.J.C.)																	
Professor																	
Upper Quartile									9000	11000	11000	11000	10300	10000	10750	9600	10750
Median									7200	8800	9300	9150	8340	8300	8000	6870	8680
Lower Quartile									6000	7550	7830	7550	7250	6900	6840	6080	7280
Associate Professor																	
Upper Quartile						7500	7270	7700	8350	8500	8450	8090	7100	7000	8200		8000
Median						6600	6700	6500	7000	7000	7000	6600	6100	6210	6300		6800
Lower Quartile						5000	5500	5400	6030	6000	6000	5910	5200	5370	5500		5880
Assistant Professor																	
Upper Quartile			5300	5500	6150	6260	6190	6500	6800	7000	6200	6240	6500	4600			6500
Median			4500	4950	5500	5520	5500	5500	5900	6000	5500	5310	5600	4360			5650
Lower Quartile			4230	4200	4900	4770	5140	5000	5200	5200	5000	4700	4810	4000			5000
Instructor																	
Upper Quartile	4000	4410	4900	5000	5300	5510	6100	6620	6100	5600	6070						5410
Median	3600	4000	4200	4770	4590	4960	5170	5200	5070	4940	5420						4700
Lower Quartile	2500	3520	3820	4200	4000	4200	4320	4070	4250	3940	4670						4000
All Ranks																	
Upper Quartile	4000	4530	5000	5200	6000	6260	6470	6870	7180	8700	9770	10030	9500	9500	10000	9370	8600
Median	3600	4000	4210	4800	5100	5400	5500	5500	6000	7000	7900	8120	7790	7600	7700	6590	6800
Lower Quartile	2500	3600	3850	4200	4290	4620	5000	4630	5200	5900	6260	6460	6500	6220	6270	5700	5500

APPENDIX C

1952 Total Engineering Income Distribution by Academic Rank

Academic Rank.....	Dean	Professor	Associate Professor	Assistant Professor	Instructor	Totals
$15,000 and over	7	74	8	1	1	91
14,500 14,999	0	6	0	0	0	6
14,000 14,499	1	8	0	2	0	11
13,500 13,999	1	7	0	0	0	8
13,000 13,499	1	17	2	1	0	21
12,500 12,999	2	14	0	0	0	16
12,000 12,499	2	43	12	4	0	61
11,500 11,999	2	22	5	1	0	30
11,000 11,499	3	48	8	1	1	61
10,500 10,999	6	20	9	2	0	37
10,000 10,499	5	72	25	6	0	108
9,500 9,999	4	56	18	3	0	81
9,000 9,499	2	69	30	11	1	113
8,500 8,999	0	63	31	11	0	105
8,000 8,499	3	105	51	22	6	187
7,500 7,999	7	82	56	29	1	175
7,000 7,499	2	78	85	54	12	231
6,500 6,999		74	81	57	11	223
6,000 6,499		55	106	112	22	295
5,500 5,999		34	79	126	26	265
5,000 5,499		17	59	146	49	271
4,500 4,999		6	33	95	65	199
4,000 4,499		2	12	59	63	136
3,500 3,999			1	17	48	66
3,000 3,499				2	18	20
2,500 2,999					4	4
Under 2,500					9	9
Totals	48	972	711	762	337	2830

APPENDIX D

ASEE Survey—Individual Media 1948–49 Ten-Months' Base Salary

Region.....	I	II	III	IV	V	VI	VII
Professor	7400	6000	6200	5100	5200	5800	4900
Assoc. Prof.	5300	4900	5000	4100	4200	4500	4400
Asst. Prof.	4100	4200	3700	3400	3600	3600	3800
Instructor	3200	3100	3100	2800	2900	3000	3300

THE T-SQUARE PAGE

CONTRIBUTIONS TO ENGINEERING EDUCATION

BY THE

DIVISION OF ENGINEERING DRAWING

T. T. AAKHUS, *Chairman*
University of Nebraska

WILLIAM E. STREET, *Vice Chairman*
A & M College of Texas

HAROLD P. SKAMSER, *Secretary-Treasurer*
Michigan State College

IRWIN WLADAVER, *Editor of*
the T-Square Page
New York University

Coordination

By FRANK A. HEACOCK

Princeton University

At the first SPEE Summer School in Engineering Drawing and Descriptive Geometry, conducted at the Carnegie Institute of Technology in Pittsburgh in June 1930, I was a member of committee No. 5 on the coordination of drawing and descriptive geometry courses with other courses. The chairman of this committee, Professor W. H. Kirchner of the University of Minnesota, presented on June 20, 1930 the following report:

In order to promote the coordination of drawing and descriptive geometry courses with other courses, the first requisite seems to be a realization on the part of the instructor of the place and importance of his work in the field of education. This requires a careful study and a sympathetic appreciation of the aims and accomplishments of related and allied departments. Because of the unlimited possibilities in the use of graphic means of expression and representation, no instructor is expected to gain a complete mastery of graphical science, but he should endeavor to raise his work, and at the same time himself, to a high professional plane.

A close coordination with the work in mathematics, mechanics, and experimental laboratories is decidedly advantageous to all concerned. While the alphabet and grammar of drawing are not to be neglected, it is well to remember that graphical language like written language is used to express thought. By gradual steps the mind acquires the ability to create images of magnitude, motions, structures, and the many manifestations of energy, including numerous purely hypothetical assumptions. The drawing department should present and develop this powerful means of expressing the concepts of the mind in a much more comprehensive and scholarly way, in both a scientific and an artistic manner.

The individual student should not be sacrificed in order to turn out a uniformly mediocre product. It is highly important to make sure that a student who has acquired a certain proficiency should not be allowed to "mark time," but should have his interest, imagination, and inventive faculties stimulated to further progress and higher achievement.

It is essential that allied departments keep in touch with each other to insure coordination and resulting profitable results. The study of graphics is sufficiently important to occupy a unique place of its own which should include all the styles of graphic expression, both pure and applied.

This sound teaching policy of 1930 is even more significant today. The importance of graphics as an essential part of engineering education demands thorough and well balanced graphics instruction that is effectively coordinated with other courses to provide the best working equipment for the engineers of tomorrow.

Teaching Tips

Making a Measuring Stick for a Horizontal Cylindrical Tank
A Freshman Mathematics Project

By WILLIAM K. VIERTEL

Instructor, State University Agricultural and Technical Institute, Canton, N. Y.

One of the most interesting and useful applications of trigonometry is the calculation of the volume of liquid in a horizontal cylindrical tank when the depth of liquid and the dimensions of the tank are known. This problem is an excellent one in having disciplinary value as well as practical value. The writer believes it deserves more attention than it usually gets, and has devised a project which dramatizes the problem and puts it in a way that appeals to students. It has been a part of the freshman mathematics work at this school for several years.

The project, in brief, is this: each student is asked to make a pattern for a measuring stick for a horizontal cylindrical tank of given dimensions. They are told only that the stick, if made from the pattern presented, should be convenient, accurate, and as nearly foolproof as possible for use by a workman lacking technical training.

They are shown how to calculate the volume for any given depth, working it out from basic principles. One or two assignments are then devoted to making the calculations. The results of the calculations are put in the form of a table, giving volume of liquid in gallons corresponding to regular small increases in depth. Each student takes the data and draws a graph, and from the graph he makes the pattern for the measuring stick.

Most students get the idea, and present patterns marked on long strips of paper with marks every 5 gallons, or whatever divisions are suitable for the size of tank assigned. Some are thoughtful and resourceful enough to add subdivisions to the major divisions. A few take some trouble with the workmanship, and bring in wooden sticks which would actually serve as measuring sticks.

It is believed that this project is of value, not only in providing motivation, but in helping to develop judgment.

Timely Tips

Dimensional Algebra

By W. A. GROSS

Assistant Professor, Theoretical and Applied Mechanics, Iowa State College

It has been the experience of the author that the subject of dimensional equations can be more understandingly presented by emphasizing the differences between ordinary algebra and dimensional algebra. The standard notations for the fundamental engineering quantities, F, L, and T (force, length, and time), are presented. The dimension 0 is introduced to represent no dimension and is applied to angles, functions of angles, or other dimensionless quantities.

In a homogeneous equation, every term set off by plus or minus signs or equal signs must have the same dimension. The symbol $\sim$ can be used to represent "has the same dimensions as." Hence all plus or minus signs are replaced by $\sim$ when writing the dimensional relation for an algebraic equation. This convention seems to be of great value to the student, for he is not confused by the ordinary algebraic symbols.

Powers or roots of fundamental quantities F, L, or T are allowable, as are multiplication and division. It should be noted that when a quantity is multiplied by a dimensionless constant, its fundamental dimensions remain unchanged, e.g., $0 \cdot F \sim F$, $F/0 \sim F$. This property is sufficiently startling to awaken interest and understanding in the student.

As an illustrative example, consider the equation for the steady state forced amplitude of a single degree of freedom system,

$$A = \pm \frac{P}{k} \cdot \frac{\sqrt{1 - (4F/\pi P)^2}}{1 - \omega^2/p^2}.$$

The corresponding dimensional relations may be presented in accordance with the preceding rules as follows:

$$L \sim \frac{F}{FL^{-1}} \cdot \frac{\sqrt{0 \sim (F/F)^2}}{0 \sim (T^{-2}/T^{-2})}.$$

The symbol $\sim$ together with the use of 0 shows immediately the fundamental dimensional relationships to the student. Homogeneity can be checked, or unknown dimensions rapidly determined.

Minutes of Executive Board

A meeting of the Executive Board of the ASEE was held in the Executive Board Room of the AIEE in New York City on Saturday, September 11, 1954 at 9:00 A.M. Those present included: N. W. Dougherty, *President;* W. L. Everitt, L. J. Lassalle, B. R. Teare, Jr., and H. K. Work, *Vice Presidents;* G. W. Farnham, *Treasurer;* A. B. Bronwell, *Secretary.*

Report of the Secretary

The Secretary reported that:

a. The Teaching Aids Bulletin is now in the hands of the press and will be completed in about two months.
b. The Committee on Evaluation of Engineering Education will probably meet at the time of the Land Grant College Association in Washington. This Committee expects to complete its work by June of next year. Approximately eight thousand copies of the Interim Report have been sold and an additional four thousand copies have been reordered.

Report of the Treasurer

The Annual Audit shows a net profit of $1,306 for the past year. Most expenses were held down because of the anticipated deficit. Also, ECRC expenses were abnormally low because it publishes its Directory and Review of Current Research every other year.

Reports of Vice Presidents

Vice President H. K. Work reported that the ECRC will publish its Directory and Review of Current Research again this year. It will endeavor to get out a book on Creativity in Research, which will be a compilation of papers on this subject presented at ECRC meetings. Also, ECRC is considering preparation of a small booklet on policy matters in relationships between colleges and government on government sponsored research. The theme for the General Session which the ECRC will program will by Education for Research.

ECRC has completed a study of Remuneration Policies in Research. It was suggested that this be published in the JOURNAL. Also, ECRC is appointing a new Committee on Research Administration. The ECRC will have a new Secretary, Dr. Renato Contini of New York University, starting September 1.

Vice President W. L. Everitt stated that the ECAC Executive Committee will meet during the Land-Grant College Association meeting in November; therefore, it has not planned its activities for the year as yet. ECAC is continuing its efforts in Manpower, International Relations, Selection and Guidance, and Secondary Schools.

Vice President Teare stressed the desirability of having officers attend Section Meetings. A tentative schedule of officer attendance at Section Meetings was drawn up.

Vice President Lassalle stated that at a meeting with President Dougherty, Secretary Bronwell and himself, the Committee appointments for the coming year had been prepared and letters inviting Society members to serve on Society Committees had been sent out. The Executive Board members emphasized the desirability of including on the Committees some of the younger members of the Society and suggested that the Chairman of YET be contacted for names of prospective members.

Proposed Study on Specializations in Engineering

Vice President Teare stated that there has been considerable interest from several sources in the possibility of conducting a study of Specializations in Engineering Education. The Executive Board voted the following resolution:

> The Board hereby expresses its interest in a possible study to determine whether or not the present curricular divisions and options as taught in engineering colleges provide the best plan for engineering education. It recommends that an ad hoc Committee of the Society be appointed to prepare a proposal for such a study and make recommendations regarding funds and personnel.

The ad hoc Committee will consist of B. R. Teare, Chairman, George Hawkins, and W. L. Everitt.

1955 Annual Meeting

The general framework for the 1955 Annual Meeting was discussed. The Board recommended holding three General Sessions on Tuesday, Wednesday and Thursday morning. It was recommended that there be no conferences conflicting with these General Sessions. It was also recommended that a General Session be held on Monday afternoon to present reports on principal Society activities, as in previous years, but that conferences should be scheduled concurrently with this Session.

It was suggested that the ECAC and ECRC again hold a joint dinner on Tuesday evening in view of the favorable response of last year's joint dinner.

The Board voted not to have a central theme for the Annual Meeting this year, in view of the fact a number of significant projects are shaping up in the Society. The General Session on Tuesday morning will include an address of welcome, the Presidential Address, a brief report on the revision of the Evaluation Report by Dean Grinter and a program to be arranged by Dr. Burdell and Dr. Gullette on the Humanistic-Social Project.

Graduate Study Proposal

The Secretary reported that an ad hoc Committee had been appointed to prepare a proposal for the Graduate Studies investigation. This Committee includes members of the Evaluation Committee and officers of the Graduate Studies Division in accordance with the request of the Graduate Studies Division.

Coordination of Projects

The Executive Board discussed the relationship of the various principal projects now under way, including the project on Evaluation of Engineering Education, the Humanistic-Social Research Project, and the Graduate Study Project. It was the consensus of opinion that these should proceed as independent investigations with overlapping membership on the Committees so as to benefit from the viewpoints and discussions on related projects. This would give each Committee maximum authority and responsibility, rather than subject their findings to review and veto power by some other group. Eventually, if there are major differences of opinion, it might be advisable to appoint a coordinating Committee consisting of members from the Committees involved to resolve the conflicts.

Placement Advertisements in the Journal

The question to whether or not individuals should be allowed to advertise for positions in the JOURNAL OF ENGINEERING EDUCATION was discussed. The JOURNAL now carries placement advertisements from engineering colleges but not from individuals seeking positions. It was pointed out that individual placement advertisements would provide increased service to the Society members. Several Board members expressed the opinion that the kind of individual who advertises for a position is often not the

better qualified individual and they were therefore skeptical about the ultimate value of this service. Also, since not many persons would advertise, this would represent a specialized service to a few members. After some discussion the matter was tabled.

1954 ASEE Summer Institutes

Vice-President Teare reported that the Summer Institute on Solid State Physics held at Carnegie Institute had an attendance of approximately 120 conferees. The program was well planned and a great deal of interest was expressed in the possibilities of realigning the physics material in the engineering curricula and adding more on Modern Physics and Solid State Physics. A final report of this conference will be prepared by Professor Glenn Murphy for publication in the JOURNAL. Wiley Book Company will publish the papers in book form.

The Summer Institute on Nuclear Science in Engineering Education at Northwestern University had an attendance of approximately 110 people. About one-half of these were engineering teachers and the other half physics teachers. An excellent panel of speakers was obtained and the conference indicated that reasonable results could be achieved in bringing Modern Physics and Nuclear Science into Engineering Education at several different levels. A report of this conference will be published in the JOURNAL OF ENGINEERING EDUCATION. The papers will be published either by a book publisher or in the ASEE JOURNAL.

Summer Institutes for 1955

Four summer institutes have been proposed for 1955 in the areas of: thermodynamics, advanced mathematics in engineering and science, coordination of sophomore level instruction in physics and electrical engineering, and coordination of sophomore level instruction in mechanics as taught by the physics and engineering departments. The Executive Board recommended that a committee be formed to review summer institute proposals and make recommendations to the Board.

Fellowship and Scholarship Proposals

The Secretary stated that several inquiries had been received from industries for information on the methods of setting up scholarship and fellowship programs. This raised the question as to whether or not ASEE should consider handling fellowships as a service to industry and the colleges. This would make it possible for industry to provide fellowships on an impartial basis without the necessity of setting up procedures for processing and awarding. A number of companies now provide for fellowships in specific universities, which removes the necessity of setting up methods of processing applications. However some companies would prefer to handle this on an impartial basis by some method which would select the best qualified student and let him choose which college he would prefer to attend. The Executive Board requested that this problem be referred to the committee which will handle the Graduate Studies project, with the request that this committee determine whether or not ASEE should assist companies in awarding fellowships.

It was suggested that the Secretary prepare a brief brochure of information which might be printed by ASEE describing how companies can set up fellowships in engineering colleges in the country.

EJC Activities

President Dougherty reported that the Engineers' Joint Council had held a meeting of representatives from the various constituent societies to discuss the possibility of holding a colloquium on nuclear energy during 1955. It was planned to hold such a colloquium and also to consider the role which the various engineering societies should take in this new and rapidly developing field.

EJC will hold an annual meeting, with

limited attendance, in January. The purpose will be to acquaint members of the governing boards of the constituent societies with current activities of EJC and get their views on principal EJC projects.

Summer Schools for 1955

The Secretary reported that the English and Chemical Engineering Divisions had both requested summer schools for 1955. It was requested that both Divisions supply topical outlines and budget information for consideration at the next Executive Board meeting in October.

Institutional Membership

The following institutions were voted into membership in the ASEE: Southern Technical Institute (affiliate membership), Alabama Society of Professional Engineers (associate membership), Capitol Radio Engineering Institute (affiliate membership), Kenffel and Esser Company (associate membership).

Activities of Public Relations Committee

The Public Relations Committee of ASEE presented some specific proposals for extension of its activities. These included: 1. Appointment of public relations sub-committees in ASEE Sections with recommendations for membership by the chairman of the ASEE Public Relations Committee; 2. Increasing the tenure of office of Public Relations Committee members and chairman; 3. Appointment of the chairman of the ASEE Public Relations Committee as an ex-officio non-voting member of the General Council. The Executive Board approved the first recommendation. With regard to the second recommendation it was pointed out that the President has the constitutional authority each year to appoint all committees. In general principle, however, the Board favored the second recommendation. It was recommended that the Chairman of the Public Relations Committee be invited to attend all meetings of the General Council without official appoitment.

Associate Institutional Members

It was recommended that a free copy of the ECRC Directory of Current Research and a copy of the Report on the Evaluation of Engineering Education be sent to each Associate Institutional member of the Society.

Next Executive Board Meeting

A meeting of the Executive Board will be held in Knoxville, Tennessee on April 16. The South-East Section meets at Knoxville on April 15–16. If it is necessary, an additional board meeting will be held in January, subject to call by the President.

Respectfully submitted,
ARTHUR BRONWELL, *Secretary*

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 17, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Brooklyn Polytechnic Institute	Dec. 4, 1954	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	April 2, 1955	M. M. Jones, University of Missouri
National Capital Area	Catholic University	Oct. 5, 1954	J. C. Michalowicz, Catholic University
New England	Massachusetts Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	A.F. Inst. Wright	Sept. 17–18, 1954	K. F. Sibila, University of Akron
	University of Akron	May 7, 1955	
*Pacific Northwest	Oregon State College	Spring, 1955	M. L. Jackson, University of Idaho
Pacific Southwest	University of California, Berkeley	Dec. 28–29, 1954	B. M. Green, Stanford University
*Rocky Mountain	Colorado A. & M. College	Spring, 1955	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9 1955	V. L. Doughtie, University of Texas
Upper New York	Cornell University	Oct. 22–23, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

ANDREWS, JOHNNIE F., Instructor in Civil Engineering, University of Arksansas, Fayetteville, Ark. L. R. Heiple, G. F. Branigan.

ASHMORE, RICHARD D., Manager, Technical Recruiting, Monsanto Chemical Company, Texas City, Texas. A. R. Wilson, R. F. McCook.

BALYEAT, RALPH E., Associate Professor of Industrial Engineering, Purdue University, Lafayette, Ind. H. T. Amrine, H. H. Young.

BANKS, ROBERT B., Lecturer in Civil Engineering, Northwestern University, Evanston, Ill. L. B. McCammon, H. P. Hall.

BECKMAN, MORRIS H., Associate Professor of Engineering Drawing, University of Wichita, Wichita, Kansas. Kenneth Rozak, M. H. Snyder.

BORDEN, ROGER R., Acting in Charge of Mechanical Engineering Department, Franklin Technical Institute, Boston, Mass. B. K. Thorogood, W. H. Perry.

BROWN, MARTIN R., JR., Instructor in Civil Engineering, Manhattan College, New York, N. Y. Brother Leo, Brother J. McCabe.

BUCH, WILLIAM G., Instructor in Mechanical Engineering, Rutgers University, New Brunswick, N. J. M. T. Ayers, C. R. G. Dougherty.

BURTON, RALPH A., Assistant Professor of Mechanical Engineering, University of Missouri, Columbia, Mo. Milo Bolstad, C. M. Sneed.

CASTELAZ, HARVEY W., Head of Refrigeration, Heat and Air Conditioning Department, Milwaukee School of Engineering, Milwaukee, Wisc. F. J. Van Zeeland, Fred Kaufmann.

CHRISTENSEN, KEITH H., Instructor in Architecture, University of Nebraska, Lincoln, Nebr. L. B. Smith, E. B. Meier.

CORKILL, PHILIP A., Instructor in Architecture, University of Nebraska, Lincoln, Nebr. L. B. Smith, E. B. Meier.

DANTONA, LEO R., Instructor in Mathematics, Franklin Technical Institute, Boston, Mass. W. H. Perry, Jr., B. K. Thorogood.

DAVIS, DALE S., Professor of Chemical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. J. W. Whittemore, W. A. Murray.

DAWSON, JAMES K., Instructor in Descriptive Geometry and Engineering Drawing, Colorado School of Mines, Golden, Colo. A. P. Wichmann, J. M. Coke.

EGRY, C. ROBERT, Professor of Industrial Engineering, University of Notre Dame, Notre Dame, Ind. H. E. Ellithorn, C. C. Stevason.

EKEY, DAVID C., Assistant Professor of Industrial Engineering, Pennsylvania State University, State College, Pa. C. E. Bullinger, R. S. Paffenbarger.

GABEL, GORDON G., Assistant Professor of Chemistry, Milwaukee School of Engineering, Milwaukee, Wisc. F. J. Van Zeeland, Fred Kaufmann.

GREEN, DUANE L., Acting Chairman—Department of Chemical Engineering, Clarkson College of Technology, Potsdam, N. Y. W. H. Allison, Charles Hecker.

GULBRANSEN, LEONARD B., Associate Profesor of Metallurgy, Washington University, Saint Louis, Mo. W. B. Diboll, Jr., C. J. Kippenham.

GURALNICK, SIDNEY A., Instructor in Civil Engineering, Cornell University, Ithaca, N. Y. J. Gebhard, G. B. Lyon.

HAMMOND, SEYMOUR B., Assistant Professor of Electrical Engineering, University of Utah, Salt Lake City, Utah. Philip Weinberg, M. E. Van Valkenburg.

HARMAN, CHARLES M., Instructor in Mechanical Engineering, University of North Dakota, Grand Forks, North Dakota. E. C. Lawson, P. J. Reiten.

HARRISON, WILLIAM P., Assistant Professor of Civil Engineering, Clarkson College, Potsdam, N. Y. W. H. Allison, A. D. May, Jr.

HAWN, HERBERT W., Associate Professor of Mechanical Engineering, Michigan College of Mining & Technology, Houghton, Mich. G. W. Swenson, A. P. Young.

HEHMEYER, CHARLES R., Instructor in Engineering Drawing, Case Institute of Tech-

nology, Cleveland, Ohio. O. M. Stone, W. E. Nudd.

HELMERS, DONALD J., Assistant Professor of Mechanical Engineering, Texas Tech College, Lubbock, Texas. C. C. Perryman, L. J. Powers.

HINMAN, GEORGE W., Assistant Professor of Physics, Carnegie Institute of Technology, Pittsburgh, Pa. E. Creutz, F. T. Adler.

HSU, SHAO T., Associate Professor of Mechanical Engineering, University of Dayton, Dayton, Ohio. A. J. Westbrock, A. R. Weber.

HUNSBEDT, THEODORE N., Recruiting & Training Supervisor, American Machine & Foundry Co., New York, N. Y. O. J. Gatchell, E. R. Heiberg.

KILBY, WILLIAM D., Head of the Industrial Department, State University of New York, Albany, N. Y. F. E. Almstead, W. H. Branch.

KNISLEY, A. WARD, Instructor, Tech Institute, University of Dayton, Dayton, Ohio. Donald Metz, Richard Hazen.

LANG, EDMUND H., Assistant Professor of Military Science and Tactics, Pennsylvania State University, State College, Pa. J. H. Moore, B. A. Whisler.

LAUER, KENNETH R., Assistant Professor of Civil Engineering, Montana State College, Bozeman, Montana. E. S. Schilling, E. R. Dodge.

MARTIN, ROBERT E., Assistant Professor of Mechanical Engineering, Texas Technological College, Lubbock, Texas. C. C. Perryman, L. J. Powers.

MORITA, KATUHIKO, Assistant Professor of Mathematics and Physics, Kanazawa University, Ishikawa, Japan. C. R. Soderberg, D. D. Adams.

MORTON, RICHARD F., Associate Professor of Physics, Worcester Polytechnic Institute, Worcester, Mass. K. L. Mayer, Ralph Heller.

NEWELL, RICHARD F., Instructor in Mathematics, Erie County Technical Institute, Buffalo, N. Y. H. A. Panton, R. R. Dry.

PAGE, ALVIN N., Head of Architectural Department, Wentworth Institute, Boston, Mass. H. R. Beatty, F. H. Linton.

PAO, RICHARD H. F., Assistant Professor of Civil Engineering, Rose Polytechnic Institute, Terre Haute, Ind. R. E. Hutchins, T. A. Duwelius.

PAUL, EDWIN W., Head of Economics Department, University of Louisville, Louisville, Ky. G. C. Williams, H. H. Fenwick.

PETERSON, MARVIN K., President of New Haven College, New Haven, Conn. L. L. Bethel, Grant Robley.

POSKANZER, SAMUEL M., Instructor in Mechanical Technology, Hudson Valley Technical Institute, Castleton, N. Y. O. V. Guenther, J. J. Fitzgibbons.

RUMSEY, GEORGE B., Representative of the College Department, International Textbook Co., Scranton, Pa. R. E. Wilson, J. C. Villaume.

SAMPSON, EDWARD C., Assistant Professor of Liberal Studies, Clarkson College of Technology, Potsdam, N. Y. D. G. Stillman, J. R. Frazer.

SAVAGE, RICHARD L., Instructor in Civil Engineering, Tufts College, Medford, Mass. F. N. Weaver, P. S. Rice.

SCHRECK, EDWARD J., Head of Physics Department, Milwaukee School of Engineering, Milwaukee, Wisc. F. J. Van Zeeland, Fred Kaufmann.

SWAIN, PHILIP W., Consulting Editor of Power Department, McGraw-Hill Publishing Company, Inc., New York, N. Y. K. J. Zeigler, S. C. Dorman.

VAN DYKE, MERRILL W., Instructor in English, Central Technical Institute, Kansas City, Mo. N. E. Vilander, C. L. Foster.

VITAGLIANO, VINCENT J., Instructor in Civil Engineering, Manhattan College, New York, N. Y. Brother J. McCabe, Brother A. Leo.

WALLS, DONALD M., Instructor, Central Technical Institute, Kansas City, Mo. N. E. Vilander, C. L. Foster.

WATSON, SARA R., Associate Professor of Chemical Engineering, Fenn College, Cleveland, Ohio. G. B. Earnest, W. A. Patterson.

WRIGHT, WILBUR H., Assistant Professor of Physics, University of New Hampshire, Durham, New Hampshire. W. B. Nulsen, E. T. Donovan.

143 new members elected this year

Do You Know—

► We have just received word from Vice President Web. Jones at Carnegie Institute that the Secretary of Defense, Charles Wilson, who is an alumnus of Carnegie Institute, has accepted an invitation to be our banquet speaker at the Annual Meeting at Pennsylvania State University. An excellent program is shaping up for the Annual Meeting this June. The ECAC–ECRC will again hold their Joint Dinner, an event which proved to be one of the highlights of the Annual Meeting last year.

► One of the General Sessions at the Annual Meeting will include a resume of results of the Humanistic-Social Research Project, which is now making very substantial gains under the able direction of Dr. George Gullette. This General Session will also present the wind-up report of the ASEE Committee on Evaluation of Engineering Education, with particular emphasis on looking ahead in experimentation and trends in engineering education. President Dougherty will also give his presidential address at this General Session.

► Another General Session will deal with the subject of Education for Research, considering the dual subject of how to educate for research and also the educational values which accrue from research. The Administrative Council is considering a General Session dealing with various successful methods which are being employed to attract and sustain interest of high school students in science and engineering.

► The local committee at Pennsylvania State University is fully organized now and is doing a grand job in planning the facilities, recreation, and entertainment for the Annual Meeting so as to make this a memorable event in ASEE activities.

► Two Summer Institutes and two Summer Conferences were approved by the Executive Board and the General Council at their last meeting. One of these Summer Institutes will deal with the subject of Thermodynamics as seen by the physicist, the chemical engineer, the chemist, and the mechanical engineer. So far, their diverse viewpoints are quite irreconciliable in both subject matter and methods of approach to the subject. It would be helpful if each understood the other's viewpoint. A cross-fertilization of ideas might yield very substantial benefits to all. The proposal is to hold a closed conference of leading authorities on this subject at Purdue University and an open conference at Pennsylvania State University at about the time of the Annual Meeting.

► A second Summer Institute, which is shaping up now, will deal with advanced mathematical methods as applied to engineering problems. It is hoped that this Summer Institute might emphasize the similarities in methods of approach in many different fields of engineering and physics. It would seek out ways of achieving greater unity in methods of presentation. The specific plans for this Summer Institute have not been formulated as yet, but we will keep you posted.

► Two additional conferences are contemplated, one dealing with the subject of engineering mechanics and the other with electricity and magnetism. These conferences will bring together leading educational authorities in these fields to

discuss the correlation of subject matter with a view toward getting a better organization of material and more efficient methods of handling these courses. These conferences will then be the basis of papers and discussions at the Annual Meeting at Pennsylvania State University.

► The Catalogue of Learing Aids will soon be available—the price $1.00 each. It lists almost 300 teaching aids which are regarded as the best available for teaching purposes. Over 5,000 aids were reviewed. Send remittance for your copy now—ASEE, Northwestern University, Evanston, Illinois.

► You can still get copies of the Interim Report of the ASEE Committee on Evaluation of Engineering Education from ASEE headquarters—price 20¢ each, or 12¢ in lots of 100 or more. Over 8,000 copies have been sold—this report has vaulted into the "best-seller" category.

► Your Secretary has been invited to take the position of President of Worcester Polytechnic Institute and will be leaving this post on February 1. It has been a grand experience to serve as Secretary of the Society for the past seven years and to have had the privilege of working with leaders in engineering education throughout the country. Naturally, it is with a great deal of reluctance that I terminate this very pleasant association. I shall always be wholeheartedly interested in the welfare of ASEE and I hope to be able to continue to assist in some of the major projects of the Society. During the past seven years, the Society has made some very substantial gains and it has stimulated a liberal outlook toward engineering education which keeps it responsive to the challenges of the advancing times. This is a high tribute to the able and enthusiastic leadership of your officers and the very effective work of many members of the Society. They have been a grand group to work with and the Society owes them a deep debt of gratitude for their dedicated service.

► We will be seeing you at the Annual Meeting at Pennsylvania State University on June 20–24. Bring the family and plan a real vacation.

Sincerely yours,
ARTHUR BRONWELL, *Secretary*

Professional Development of Engineering Teachers*

By N. W. DOUGHERTY

President of ASEE, Dean of Engineering, The University of Tennessee

You are fortunate in living in a day which is fraught with change and a consciousness of change. Teachers do not expect to make an outline today which will last for several years; they expect to make improvements every time they give the course. Their time may be expended on their work in an atmosphere of research, writing and teaching without having to consider whether science and technology will be acceptable to those who administer the college or university.

The battle of science and utility has been won; our forebears have placed engineering teaching on a parity with any kind of education. We do not need to defend ourselves against educational critics, since our type of education has general acceptance. Herbert Spencer, and a long line of science and engineering writers, have placed utility education alongside any other type of teaching which has survived the changing times.

One hundred seventeen years ago Emerson,[1] made a prophesy which has come true:

> Our day of dependence, our long apprenticeship to the learning of other lands, draws to a close. The millions that are around us rushing into life cannot always be fed from the sere remains of foreign harvests.

Engineering teachers have not only won the battle of acceptance into the halls of the educated, but they have declared their independence of any other cultures. Delegations from other lands are coming to us to learn our methods of applying science to industry with such abundant harvests. We have developed our own method of education, we have produced our own literature of engineering, we have built our own kind of civilization. In our thoughtful moments we will find errors; we will make some real changes, but the kind of teacher you are destined to be is indigenous to our soil.

We must make college more than a place to gather information about earning a living. It must be a place where the torch of learning is lighted and will continue to flame through a whole professional career. It is more important to get the spirit of the scholar than to learn the multiplication tables or Newton's laws, though these too are essential.

Our education is slowly evolving from the study of an art and method to a study of basic laws and reasons why. Engineering and agriculture were the first major disciplines to come out boldly for utility, and the application of science to foods and production; we learn mathematics and science because they are useful in making a living.

The educators of the last century looked at our predecessors as if they were committing sacrilege when they elevated technology to a college curriculum. Hear this from the beginning of the last century:[2]

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* Presented at the Young Engineering Teachers Banquet, Annual Meeting of ASEE, University of Illinois, June 14, 1954.

[1] "The American Scholar," Ralph W. Emerson.

[2] "Democratic Education," Benjamin Fine.

With the study of the Greek and Latin languages, sound learning flourishes or declines. It is now too late for ignorance, indolence, eccentricity, or infidelity to dispute what has been ratified by the seal of the ages.

Now the seal of the ages has been attached to the kind of education which we foster, though we still have a few small voices who would turn us away from the task of teaching the things which the students need to know.

When I first prepared this outline I was tempted to dwell upon your first five years of teaching. I outlined many of the problems such as routines and elementary work, small compensation and the balancing of budgets, the beginnings of a family, supplementary income, the virtues of extra work and summer employment, apparent neglect by superiors, hack-work, delay in promotions and that *advanced degree*. I did not have a ready solution, except persistence and hard work. Then I realized that you knew the problems as well as I did, and that no useful purpose would be served in dwelling upon palliatives.

For those who can take an advanced degree in their stride, it is a worth while achievement; for those who have had to extend themselves, it is the top rung of their educational careers. They go from there as wells which have been pumped dry, as springs which have had the pall of drought placed upon them. Their energy is spent, their ambition is gone, henceforth, they must assume the role of critic and pedant.

Those who take the doctorate in their stride think of it as an incident rather than a goal. They go on to new problems and new methods, always seeming fresh and ready for new developments.

Love for Teaching Essential

Dean Hazen in his "Letter [3] to a College President" has placed the following valuation on advanced study: "In a case of a man in his 30's, or even 40's, we are interested to see if he has a doctorate, since if he has, it is evidence that he has had sufficient scholarly interest to go on for graduate work and research. But the doctorate of itself is neither necessary nor sufficient evidence of the quality for which we are looking."

Of greater importance than advanced degrees is interest in and love for teaching. It is more than just a way of making a living, or even a desirable occupation; it is a dynamic way of engaging a life work. One of the keys to good teaching is expressed by William L. Phelps: [4]

I do not know that I could make entirely clear to an outsider the pleasure I have in teaching. . . . In my mind, teaching is not merely a life-work, a profession, an occupation, a struggle: it is a passion. I love to teach. I love to teach as a painter loves to paint, as a musician loves to play, as a singer loves to sing, as a strong man rejoices to run a race.

If I can help you get enthusiastic about teaching, I will do you a greater service than to tell of the rough places and suggest ways of getting over them.

In teaching there is no substitute for knowledge of the subject, but that is not enough. The good teacher has love for his work; he has a sense of humor, is energetic, has personal charm; he is a director of discussion and not a tyrant; he is a teacher of students rather than of subject matter.

There are available many books and magazine articles on the art and science of teaching. It will be worth our while to mention a few and suggest that you enlarge the list by constant study in the field. A number of year ago I acquired a copy of "An Open Letter to College Teachers," by Payne and Spieth, which was very helpful. If you have read it you will find that many of the ideas I

[3] April and May 1954 issues of *Electrical Engineering*.

[4] "Teaching in Schools and Colleges," Phelps.

have expressed as my own have parallel expression in the book. It is a down-to-earth analysis of teaching which notes the virtues of good teaching and recognizes the faults of the poor teacher. Chapter VI suggests a study of the methods of great teachers and gives some brief notes on a few who have been nationally recognized as being very good. This chapter has a special appeal to me because I think biographical studies are good in science, in engineering and in teaching. I suggest a reading of Conant's little book "On Understanding Science," an historical approach, as a sample of the method and approach.

"Teacher in America," by Jacques Barzun, is very readable and it gives a rather unique approach to the subject of teaching. A sample paragraph will give a taste of his method:

> It takes the stubborness of a saint coupled with the imagination of a demon for a teacher to pursue his art of improvisation gracefully, unwearyingly, endlessly.
> Hence young teachers are the best; they are the most energetic, most intuitive, and least resented.
> Consequently, the whole aim of good teaching is to turn the young learner, by nature a copycat, into an independent, self-propelling creature, who cannot merely learn but study—that is, work as his own boss to the limit of his powers.

Engineering teachers have been prone to look down their noses at the works from the college of education, and I must admit that many of their books are not very impressive, yet they are specialists in their fields.

William James was a prophet and priest of educational psychology toward the end of the last century. His talks to teachers are still readable today:

> The genius of the interesting teacher consists in sympathetic divination of the sort of material with which the pupil's mind is likely to be already spontaneously engaged, and in the ingenuity which discovers paths of connection from that material to the matters to be newly learned.

Tie the new idea to the old or one which has interest to the student, and he will grasp the new idea without initial resistance. You will note that the quotation from Barzun suggests that the young teacher is the best. There is much good evidence to support this view.

Biographical Approach

A sample of the biographical approach to teaching is given in the sketch of Bliss Perry, by Rollo Walter Brown, in *The Atlantic*, June, 1954. In describing his work, Mr. Brown says:

> They listened. They passed the word along that here was a man with something important to say. . . . He experienced a vast and honorable repute, and like any other sensitive, intellectually honest human being—like William James, for instance—he was deeply concerned that the repute be deserved.
> They knew that Bliss Perry was a great teacher. But as in the case of any other great teacher, they found it next to impossible to agree on what made him so. . . . The revelation comes—as far as it ever comes—through unanticipated overtones that later seem only evidences of the teacher's good sense; through the attitude always maintained by a teacher toward the taught; through what he does supplementary to his teaching; through the restorative concerns when he is entirely away from the world of the classroom.
> The overtones made it easy enough to feel the first purpose of Bliss Perry's teaching: he was an awakener.

We have all heard a college likened to a log, with a student on one end and Mark Hopkins on the other. This is a remark attributed to President Garfield, who was a graduate of Williams College when Hopkins was there as president and teacher.

> The man Mark Hopkins as he moved slowly forward through the elm-shaded street seemed to incarnate in his stately massive form and wide domed brow all the traditions of the old school, preserving its reverence for God and man, its high sense of

duty and justice, while he cast out all that was narrow and petty and looked out to the new vistas of knowledge opening before him with wide vision and deep understanding; holding fast to all that was best in the old and opening the way to that vast conception of the universe that was just beginning to dawn upon the mind of man.

"Biography of Mark Hopkins,"
J. H. Denison.

While the appearance of the teacher is not all important, it helps if the teacher looks his role. Professor Church was a little man, yet he was looked upon as a great man; Mark Hopkins was a big man, and his size helped to set him alongside the great.

We have given brief sketches of a few great teachers, let us close this part of the discussion by mentioning a few things which we all know. "All wish to be learned, but no one is willing to pay the price" was said by Juvenal at the beginning of the Christian era. It is as true today as it was centuries ago. Few students have the will and the compelling desire to get a real education. Much of our time must be spent, as was that of Ichabod Crane as "with the appalling sound of the birch, he urged some tardy loiterer along the flowery path of knowledge." We do not use the birch, but we are familiar with its equivalent in low marks and administrative discipline.

Much excellent material has been developed outside of the college of education. The JOURNAL OF ENGINEERING EDUCATION is filled with papers describing methods of teaching, methods of conducting laboratories, the objectives of certain courses, the place of subject matter, and the necessity for enthusiasm.

Homo sapiens learns in a certain way, and there is little profit in trying to teach him by other methods. He forgets at a certain rate and the teacher is barking up a tree when he insists that something was learned last year and he cannot take time for it today. Many things learned last year are forgotten, other things learned this year will also be forgotten; the teacher should recognize these facts and teach accordingly.

Good Teachers Rare

Good teachers are so rare that the rumor of one on the campus spreads with the speed of gossip.

There can be no doubt about the fact that the key to any program of effective instruction is dependent upon the instructor and not on the organization of the material, or the sympathy of the administrator, or even the instruction materials. Above all the helps, the devices and the equipment is the work of the teacher himself.

Personal interest and deep concern about the student vastly enlarge the horizon and greatly stimulate the effort.

It is good to mix theory with practical experience, by such a mixture both experience and theory are motivated. Long ago Vitruvius gave this advice:

> Architects who have aimed at acquiring manual skill without scholarship have never been able to reach a position of authority to correspond to their pains, while those who relied only upon theories and scholarship were obviously hunting the shadows, not the substance. But those who have a thorough knowledge of both, like men armed at all points, have the sooner attained their object and carried authority with them.

I cannot emphasize too much the desirability of acquiring some engineering experience along with the teaching. My best advice is to get such experience during the summer months, rather than to take off several years and enter industry. My experience in employing industrial workers as teachers has not been too promising. Leaven the teaching with engineering experience rather than leave teaching to spend long periods in industry.

To develop a spirit of unity in engineering and a professional attitude the teachers must become professional practitioners as well as educators. This does not mean that they must have intense

industrial experience, but rather that they take an active part in the movements designed to achieve professional recognition.

Professionalism has different meanings for different people, depending upon the context and their background. I wish to define the word for our purposes as meaning those attitudes and activities which distinguish a member of the "learned professions" from the skilled trades. Engineers' Council for Professional Development[5] has listed certain distinguishing characteristics of both a profession and a professional. Among those for a practitioner are ethical conduct, a service motive, a relation of confidence and membership in a group. A teacher must be thoroughly familiar with all the implications of professionalism, since most of the teaching in these areas is by contact, contagion, and example, rather than by class assignment and laboratory exercises.

Teachers must have enlightened ideas on such problems as fragmentation of the engineering profession. Year after year the number of new curricula and new options increase; nationally and locally the profession is organized into many separate groups. We talk about unity; we organize for unity, and yet each group goes its merry way breaking into smaller groups. Unity in the profession will probably come after a new generation of students has been conditioned for it. Should we emphasize the common elements in engineering education rather than the specialization we might take the first step. Teachers must become thoroughly familiar with the vested interests now causing slow progress toward unity, and then send out their students with a will to do something about getting it.

Recognition

For many years we have talked about recognition. Two wars have focused the light of publicity on the profession in such a way that all know engineers as the key to production and distribution. Further recognition is obtained by defining a professional and separating him from the interloper.

This is done by active participation in the technical societies, by support of the registration movement, and of course, by being an engineer worthy of the title. Much has been written about the effects of registration. Some of the claims have been very sanguine. and some of the criticism has been unfounded. We know that registration is here to stay; we know that thousands of engineers are registered in the several states, and we further know that to practice the profession an engineer must be legally registered by his state board. I do not go as far as the majority of the National Council about teachers, but I believe it is to the great advantage of the young teacher to get registered in his own state as soon as he is eligible. As court decisions accumulate, it becomes obvious that a registered professional is in a much different legal position from his colleague who is not registered.

I need not mention ethics, service and the relation of confidence except to say that students admire and imitate their teachers. They are very similar, except they are a little older, to the youngster who was following his dad to the garage. A little snow was on the ground, and the youngster called "Daddy, I'm coming." The father looked back and saw that the youngster was stepping in his tracks. He realized more than ever that, in fact, is what youngsters do.

Henry Van Dyke, in Little Rivers, makes the statement that the last touch of beauty is animation. I am convinced that the last touch of good teaching is enthusiasm and interest in those who are taught. Students cannot be treated as numbers; they must be treated is individuals. John Henry Newman in describing a university said: "An alma mater is a loving mother, knowing her children

[5] Report of Committee on Professional Recognition, ECPD, 1945.

one by one." The good teacher must know his students one by one, and his contact must take the nature of individual rather than group activity.

As I look at teaching for the next several years I am enthusiastic about the prospects. It is probable that the compensations will never be competitive with industry, but neither will industry be able to compete with the satisfactions which are available to the interested teacher. Engineering teaching will be doubly attractive, because of the possibility of industrial as well as educational interests.

A new age seems to be dawning. It is probably the logical development of the industrial revolution which has been on its way for nearly two centuries, and yet each generation during the revolution has had the feeling that it was at the cross-roads of progress. So is every generation; so are we; so will be our successors. In the great movements of civilization it may be that the individual cannot hinder, yet the record seems to show that individuals do add to its ebb and flow.

This quotation from the first paragraph of Harrison's "Atoms in Action," points to a new shore of Newtonian pebbles to be picked up by the next or the next generation:

> Whether yesterday was sunny or cloudy, a June day or a day in December, enough energy fell on the earth during that twenty-four hours to serve humanity for several centuries—enough to keep the world's furnaces roasting and its refrigerators icy, to spin its wheels and refine its ores, and to fill for several hundred years every other present need for power. The wheels of civilization are kept turning by energy; and all the energy, whether drawn from a gallon of gasoline, a ton of coal, or a pound of butter, has come from the sun.

This statement is obviously dated before 1945 and does not consider the energy of atomic fission. Yet the possibilities of capturing the energy of the sun poses a problem which some student will solve, and it may be that he will come from one of my classes or from one of yours. If we as teachers can stimulate students to search and to find we will multiply our efforts many times.

The Flight of Human Imagination

At each annual meeting of ASEE for the last several years we have had programs which undertook to look into the future of atomic fission. Each year new progress is reported; each year we realize the devastating effects of explosive use. We then look into a more distant future and see wheels turning, ships sailing, planes flying powered by this new energy. We dream of the new methods of constructing prime movers, we realize with Kettering that the only limit to new devices, new methods and new ideas is the flight of human imagination.

The young teacher of this generation will have to prepare engineers for next year and the next twenty-five years. He must grow with them, he must be able to inspire them to continue studying until the end of their careers.

If the teacher is enthusiastic about his work his students will respond; if he believes his work is drudgery his students will have the same attitude and no education will result. It is not telling them what they need to know; it is helping them find out for themselves what they need to know.

As one who has spent many years on the path I have traveled, you may wonder whether I would like to travel over the trail again. Had I to live it over, I would choose about the same life, with a little more study and a better husbanding of my financial resources, but with no major changes. It has been very pleasant indeed; the friends I have made; the books I have read; the classes I have taught, all are nostalgic to me.

You are at the beginning of the broad highway; the direction signs glare in neon lights, but some of us are like the old WPA worker who was also studying by class extension. He was poring over

his work when the teacher asked him how he was getting along: "On a road sign I have learned to tell how far, but I can't yet tell where to." This much we know: it will be a lifetime of activity, but we are not sure of the direction all the way.

Always there is expectation. The next fifty years will be more active than the last one hundred, yes maybe, than the last thousand. New knowledge may burst upon you like an atomic bomb, or it may come as it did to Elijah, in the still, small voice. Be awake and in tune in order that you may hear, whatever its tone and language. I can do no better than to close with the lines of Matthew Arnold:

> Life consists not in getting and holding, but in being and becoming.

In the News

Architectural and engineering plans are nearing completion for the new headquarters building in Washington, D. C., of the **National Society of Professional Engineers.** Located in the Northwest section of the Capital, the approximately $300,000, four-story, granite frame building will house the executive and administrative offices of the 33,000 member Society. Financing of the new headquarters will be handled through the sale of building fund participation certificates to the membership.

ANNUAL MEETING

June 20-24, 1955

Pennsylvania State University
State College, Pa.

Sons of Martha; In University Halls, In Professional Practice, In Community Upbuilding, They Serve*

By W. R. WOOLRICH

Dean of Engineering, The University of Texas

About three years ago, the members of the American Society of Civil Engineers in planning a fitting celebration for the centennial of their origin sought out the proper officials in Washington and persuaded them to design and distribute a commemorative postage stamp that would pay fitting tribute to the professional engineers of North America.

The ready response of the Post Office Department was commendable but their judgment and knowledge of professional engineers came up short. As you will recall the first stamp issued was to the honor and glory of one Casey Jones!

Now all Americans enjoy the folk lore and the legends of the unusually rugged individuals who were so unique that they highlighted the parade of humanity in the growing up of our frontier states, and in this group we would pay homage to the recounted prowess of railroad engineerman Casey Jones. This does not, however, justify an authorized official of a great nation in making a selection of this driver of a throbbing locomotive as typifying the great contributions of the professional engineers of our nation for the current century of oustanding constructive accomplishments.

There are many millions of the people of this land to whom the professional engineers of America need to dramatize the high calling of professional engineering and of the commissioned registered engineer, without reducing the acclaim and the earned recognition that might rightfully belong to the enginemen, the surveyors, and the servicemen, these noncommissioned tradesmen that undergird the engineering profession in no small way.

It does give us reason to ponder, however, whether every technical man who has acquired eligibility for professional recognition in his state or province should not accept the privilege of acquiring a commission as a duly registered professional engineer in his state. This in itself will differentiate him from the noncommissioned tradesman within his community and commonwealth.

The Casey Jones commemorative postage stamp episode reveals, moreover, to the more than 400,000 professional engineers of the United States that we have done a poor job in defining the profession of engineering to an important segment of the American people.

In Rudyard Kipling's poem, "The Sons of Martha," dedicated to the Canadian Professional Engineers, we have a more enlightened interpretation of the engineer as he is envisioned in verse by that genius of adroit humor.

The Sons of Mary seldom bother
For they have inherited that good part
But the Sons of Martha favor their mother
Of the careful soul and the troubled heart

* Paper presented at the Allegheny Section meeting, ASEE, Pittsburgh, Pa., April 30, 1954.

And because she lost her temper once
And because she was rude to the Lord, her guest
Her Sons must wait upon Mary's sons
World without end reprieve or rest.

Legion are the professional engineers of this land who have given true fulfillment to Kipling's lines of appreciation. From George Washington to the newest recruit from our engineering colleges the men who have served and developed this nation might repeat with true pride that last paragraph of that scroll of the Engineer's Council for Professional Development which reads—

"To my fellows, I pledge, in the same full measure, I ask of them, integrity and fair dealing, tolerance and respect, and devotion to standards and the dignity of our profession, with the consciousness, always, that our special expertness carries with it the obligation to serve humanity with complete sincerity."

If we are to inspire by our ability and ardent desire to serve, may it be with some equity of emphasis within our homes, in the local community with its civic organizations, in the church of our choice and for our government as it might challenge the best that is within us. In these efforts we can serve our profession by example and by precept. With the writers of the old we can say, "He profits most who serves best."

Three Major Factors

The three major successful factors that place engineering as a distinctive profession apart from all others are (a) the ever recurrent demonstration of the abilities of its members to create the new, (b) the tireless devotion of the men of the profession to utilize what has been discovered for the betterment and advancement of mankind, and (c) the determination of the leaders of the profession to conserve and preserve with social and spiritual integrity the God-given resources of their homeland not only for the present but also for future generations. Briefly then, it is an engineer's mission to create, utilize, and conserve.

When you examine these three factors, they offer an advancing progression of opportunities. The "creative" originates with the most simple known values, then evolves into that which progressively becomes more complex. Each discovery just increases the possible permutations and combinations of more new inventions. It was the creative ability of early engineers that gave the profession its name. Engineur, from which Latin base "engineer" is derived, means "a genius of creative ability." The engineer's contribution in utilization sets him very definitely apart from the fundamental creative scientists such as the physicist, the chemist, or the geologist, in that the applications of scientific discovery for the usefulness of mankind is the engineer's unending pursuit. It is through his efforts that the fundamental science discoveries of the pure scientists finds an outlet and a usefulness in our world of industry.

But it is in conservation that engineering moves up into its highest effectiveness. The greater the scarcity and importance of a resource, the more certain the public can be, that the engineer, either by improved design, or by judicious substitution will determine economies that will extend the life of critical reserves.

It is of interest also that in his evolution, the engineer has risen through three distinctive stages of up-grading which we might designate as birth, growing up and maturity. In his first appearance, or birth, in world affairs, he was charged to create war machines for the ever-recurrent combats for racial survival. In this, he was not fulfilling his higher mission of creating, utilizing, and conserving, but was called upon to create, utilize, and destroy.

Historically, it is most fascinating to watch the cavalcade of these early creative mental giants as they broke through the crust of their distasteful heritage.

They moved into the second stage of their development as professional men of constructive ideals and became founders of civil life engineering by consecrating their talents, services, and genius toward useful designs and construction between wars. They began with such static creations as dams, aqueducts, bridges, and canals, then in subsequent generations moved up into the dynamics of production machines, steam engines, locomotives, and gas power—thence proceeded to areonautical flight and to metallurgical and chemical processes and are today in the front lines trying to direct the energy of the atom for a wide range of helpful applications.

In moving through these several advancements as civil life engineers, they experienced the third evolutionary stage of growing up as a profession. The advent of this final period has an American birthright. Strangely enough, it was ushered in by the Continental Congress of the United States when these three master minds, George Washington, Benjamin Franklin, and Thomas Jefferson set up the procedures and principles which guaranteed freedom of thought and action to the American people and then proceeded to implement a program of higher education to insure the conservation of our national resources by the educational process.

This third period which nurtured the engineering profession to maturity was ushered in by the organizing of Universities and Colleges for Engineering Education. Note that this was on American soil where freedom of constructive thinking and acting had been guaranteed by our national constitution based on democratic principles. Here in the United States the first university degrees for engineers of civil life were earned and conferred.

How well these three great men planned and spoke when they described the way in which this nation would make democracy work by setting up a system of of higher education that was yet unborn but that would be a guarantee and an insurance that this nation would thrive and endure.

Freedom To Act and Think

That the freedom of thought and action has produced excellent results is indicated by a reappraisal of the great inventions of the past one hundred years of the nations of the world. Of the one hundred greatest inventions of this period, the United States has more than her quota. A surprisingly large number of these were brought forth by transplanted Europeans who found the freedom of our nation a fertile ground in which to nurture their ideas. In the American quota of the greatest inventors, you will find such names as Steinmetz, Pupin, Baekland, Sirkorsky, and Zworykin. Each of them has revealed that it was the freedom to act and think in this country that caused him to transfer his affections from a native to a foreign home, and each in his turn has made a real contribution as great American citizens. Also during this same one hundred years of history, professional engineers have revealed their true capacity as men of ingenuity whose contributions to peace have far exceeded those to war. Every succeeding conflict reveals more and more dependence of nations upon engineering technology. The research scientist and the professional engineers are in the front lines of national defense of all modern nations when their freedom is threatened.

It is ironical that since the dawn of history, the engineer in times of war emergencies has carried the burden of defense for his fellow men as the creative genius of design, construction, processing, and in the management of men, machines, and materials. Whenever war clouds threaten, their fellow men urgently appeal to them to prepare the country for its defense but when the conflict is over these same engineers can expect to hear criticisms that are scornfully

derogatory of their war time contributions.

After each of our American wars, the professional engineer and applied scientist has ignored these poison darts of ingratitude and carried on with even greater responsive enthusiasm to rebuild, re-direct, and conserve the best that can be salvaged from each succeeding conflict.

This is the profession of which you and I are a part. We can be proud of the fact that the engineering profession has more to do with the conservation of our nation's resources than any other professional group. May we with equal humility recognize that in fulfilling our entire obligation in such a role we are only doing a small part of what this opportunity offers.

To be more specific, all of our nation's resources can be divided into three types (a) natural, (b) education and equipment, and (c) social and religious. It is in this higher trinity of our professional relationships that we should be most concerned.

For several generations, the Christian Associations have used as their symbol the equilateral triangle with the three sides labeled "Spirit-Mind-Body." May we, as professional engineers, look upon our triangle of resource conservation as being made up of three types of national resources, namely, natural resources-education and equipment—and our social and religious ideals. In this you have the picture of our higher trinity of opportunity in conservation.

We are vitally interested in the conservation of our natural resources which include materials, energy, and men. This represents one side of our triangle. In periods of abundance, the human being becomes most wasteful of these and dissipates them with wanton recklessness.

As a national example of our material wastefulness, it is not too far back for most of us to remember the shameful mis-use of our forest resources. Only yesterday, did we become concerned about our soils and our phosphate reserves, and only today are we tightening up on our natural gas reserves.

In energy reserves, the price of fuel had to rise to high levels before we could convince ourselves that it was wasteful to let the energy of our rivers go to waste. Yet all of the time we recognized simultaneously that our fuel resources were depletable and that water power energy must for the most part be used when it is available for the more we use it for power development the less damaging by floods it would be on its way to the sea.

Conservation of Men

In the conservation of men, only the free nations have held any high appreciation of the dignity of man. The early examples of dictators creating some giant task like the pyramids to keep slaves out of mischief, or the Roman games to reduce the number of Christian believers, or the Crusades to arouse a loyalty of restless subjects to certain barons or the more recent exhibits, first in Germany and now in Russia, of human extermination to make the world safe for the privileged few—these should make us pause in appreciation of the Bill of Rights of the United States or the Magna Carta of Great Britain.

As engineers and creative scientists, we can point with pride to the National engineering societies for the part they played in giving the human factors in management a front place in their past twenty years of endeavor. Both from statistics and from personal observation, the speaker is convinced that Great Britain and western Europe trail far behind the United States in their attempts in the management of men.

If we look next to the second leg of the resource triangle and recount the engineers' contribution in developing this second resource—education and equipment—we find a close mutual relation-

ship. It has been by education that engineering arose to maturity as a profession and it has been the scientist teamed up with the engineer that has made the world's greatest contribution in the design of equipment and tools of production.

When we as men and women observe that civilization itself had more natural resources during the cave man period than exist today, yet that in food, rainment, and shelter the cave dweller possessed only the most crude necessities, then we can more greatly appreciate this evolution of man by his creation of tools and his education in the knowledge of how to use them. In this evolution, appreciation for art, music, and the sciences are all a part. The engineer's portion of this cavalcade of progress has been primarily to solve those most difficult problems that required scientific analysis and inventive development.

The third log of our triangle—social and religious ideals, is probably the resource which engineers have been prone to overlook as not belonging in their sphere of activity. Thank God engineers are today moving into the center of it where they belong.

If this nation would retain its position of leadership, more technically trained leaders with dynamic courage and unimpeachable integrity must accept the obligations in the fields of human engineering, civic righteousness and high level statesmanship.

The reputation of engineering education in North America has been established primarily on the productivity genius of our American engineering college graduates. Europe and Asia recognize us for this genius in production. A large segment of our registered professional engineers of the United States and Canada belong to the group of graduates who have earned their professional status by production, operation, construction or management.

The engineering sciences must be advanced in most engineering curricula, but this should not be at the expense of our accomplishments in industrial engineering and management. All western Europe and much of Asia are determined to try to overtake us in industrial activity. We should not reduce our rate of advancement in industrial engineering but raise the level of what we have in that field as well as direct our attention to new high levels of accomplishment in the engineering sciences.

Greatest Task Ever Given To Mankind

Since the dawn of history whenever the moral and spiritual fiber of a people shriveled up, they have been overpowered by their adversaries. At the present moment this nation is confronted with the greatest task ever given to mankind. The world over we have democracy being challenged by a philosophy of communism. The professional engineer and the scientist are and should be right in the midst of the present international action. Those who will accept the challenge with a complete concern and devotion to the higher instincts and convictions of their being will come forth as greater professional men and citizens than civilization has ever yet produced and as creative scientists, conservationists and professional engineers, let us not forget which of these resources controls the rises and the falls of our civilization.

It would be well to digress briefly and examine our obligations as engineering teachers to the engineering profession and then in turn examine the ways in which the professional engineer can work more effectively with the engineering colleges, in a concerted program of resource conservation and human betterment.

Much has been said about increasing the number of business and humanities courses in the curricula of enigneering. As a Dean of Engineering, I can report from experience that a fortnight seldom passes that some ardent progressive pro-

moter does not urge that we add just one more course to our already overloaded program. Most engineering curricula today require as much work for a Bachelors Degree in Engineering as is required in the same institution for a Master of Arts and most of us are aware that each course in engineering is a more rigorous discipline than those in the Arts degree plans.

The first responsibility of a College of Engineering is to produce graduates who can qualify in their own field of specialization. You cannot dilute the curricula beyond certain minimum standards and still have a man acceptable to the Registration Boards of the states and provinces of North America.

The survey made in the State of Pennsylvania in 1938 by Dr. Learned gave interesting evidence that the product of our engineering colleges is far above the average in cultural attainment. Yet the proponents of general education are trying to make the world believe today that something should be done to save the souls of the men who are educated in the specialized professions, especially engineering.

Recently, a poll was made of the men and women of Chicago who had made the greatest contribution to that city by their lives of usefulness and preeminent services. When the tabulation was completed nearly seventy per cent of those selected were from the professions. When you consider that the proportion of college graduates in Chicago with a Liberal Arts College education outnumber those with a professional school education, it would seem that our general education friends need to make a new appraisal of their philosophy of life preparation.

The present trend is for the industrialist who employs science and engineering graduates to provide a program of expected reading and self development in the areas related to business, to management and to cultural betterment. The recent reports from a large segment of American industry to the Committee on the Evaluation of Engineering Education approved the proposal that universities should devote a full measure of any available time to improving the level of scientific education of their degree candidates that industry should then take the ball from there and give a complementary education in business training, management and public relations.

Those of us responsible for teaching the rigorous disciplines of engineering might gather some solace from the poet's pen when he wrote:

> Good timber does not grow on ease
> The stronger wind, the tougher trees
> By sun and cold, by rain and snows
> In tree or man, good timber grows.

Personally, I have full confidence in the professional engineer as a product of our American engineering colleges being ready to take his place in the complex life of our nation.

The urgency of the hour does demand that each of us must take our share of responsibility to be complete professional engineers and assume our full obligations in conserving not only our "natural resources" or our "natural resources and tools and equipment"—but we must go all of the way and claim our place in the civic, and cultural and the religious activities of our community, our state and our nation.

And let us not overlook the fact that the financial capital of the world has moved to the American continent and that this has happened within the two past decades. This also in turn places increased obligation upon our international stewardship of wealth.

Our natural resources might deplete a small percentage of the total from year to year but such depletion, except in case of all out war, will happen very slowly. Our education and equipment will generally be an advancing resource, but our social and religious philosophy is a less predictable variable and let us re-empha-

size again it constitutes the controlling force in this resource trinity.

Blue Print For Advancement

In closing may I bring this talk down from the general to the specific. As a blue print for the advancement of the professional engineer for the decade immediately ahead might not our educational program include a cooperative assumption of responsibilities on the part of each of us. Such cooperation should include both educators and practicing engineers as presented herewith:

As individual teachers in the classroom that we will:

1. Inculcate high regard for safety, ethics, and public and community service and responsibility in every major engineering course.
2. Give increased emphasis to creative thinking in each engineering course and encourage men of creative ability to attempt the unusual.
3. Encourage the man with a high level of engineering ability to carry on through the Master's degree.
4. Give encouragement to the geniuses among us to move to the Doctor of Philosophy degree. These would usually be the proven men with an Army General classification score of 130 or above.
5. Participate whole heartedly in the community and professional life of which we are a part.

As administrators in engineering colleges:

1. Aim towards an up grading of the quality of students pursuing engineering in order that we may more certainly justify full professional recognition of engineers among the profession.
2. Maintain a high level of the engineering sciences and mathematics as a core to all engineering programs.
3. Extend the recruiting efforts to the rural high schools where the percentage entering college is usually low. This may provide a net increase of 10 percent of graduating engineers of high quality and ability.
4. Develop more short term advanced engineering courses of graduate level to enable men of the profession to acquire knowledge of the new advances in engineering science and technology to keep abreast of the more recent graduates.
5. Encourage all engineering teachers to quality for registration in their respective states.
6. Encourage every engineering teacher to engage in current engineering practice during his spare or summer vacation periods so long as it does not interfere with his teaching obligations and also that he conform to salary schedules equal to or above those recommended by the profession.

As practicing engineers in the profession:

1. Maintain an alert guardianship of the profession against an enforcel leveling of the individual by engulfing graduate engineers in unionism.
2. Encourage more employers to improve the spread of salaries to show a full recognition of years of competent high level service.
3. Expand the current trend of employing companies to give further education in management, in sales and in cultural reading assignments to supplement the technical and scientific education of the college.
4. In each state press for a fair proportion of engineers and industrialists on the College and University Boards.
5. Improve the necessary procedures to afford greater recognition of engineers in public and national life.
6. Encourage the registered engineers of North America to campaign for a level of engineering teachers' salaries in each state and province equitably adjusted to comparative levels with law and medicine.

Nationally our march of progress

should envision an America growing deeper in its scientific, cultural and spiritual foundations, fully capable of directing the distribution of our financial resources through a personnel well educated in the principles of science and engineering from the basic fundamentals to their various applications. These scientific principles should be effectively applied to the management of men, the development of power, the utilization of materials, the transportation of man and the distribution of his goods for the benefit of the human race. I predict that as true "Sons of Martha" we will meet this challenge.

Experiments Invited for Taylor Memorial Laboratory Physics

The American Association of Physics Teachers is undertaking the production of a book of Advanced Undergraduate Experiments in Physics, as a memorial to the late Lloyd William Taylor. The material is being supplied by the teachers of such laboratory courses; some one hundred physicists have contributed experiments and suggestions. In spite of this fine response, there may be many other interesting and illuminating experiments yet to be contributed, and these experiments also should be included in this book, to give them wider circulation and thereby to enrich the instruction in advanced physics courses. Every effort is being made to obtain them.

Although the primary responsibility for this book belongs to A.A.P.T. members, contributions are cordially invited from all physicists and from colleagues in other sciences, outside the United States as well as inside. All fields of physics are represented. Informally written notes, or laboratory instructions as used by students, are quite satisfactory, since the editors must pull all material into publishable form. To be of use these experiments must reach the editors not later than March 1, 1955. They may be sent to T. B. Brown, The George Washington University, Washington, D. C., or to the appropriate editor. Sections and editors are—*Mechanics:* R. H. Bacon, 405 Bedford Road, Pleasantville, N. Y. *Heat:* R. L. Weber, Pennsylvania State University, State College, Pa. *Acoustics:* L. R. Weber, Colorado State College, Fort Collins, Colo. *Electricity and Magnetism, Electronics:* M. C. Harrington, Drew University, Madison, N. J. *Optics:* H. A. Nye, Cornell University Aeronautical Laboratory, Buffalo, N. Y. *Atomic Physics and Spectra:* S. C. Brown, Massachusetts Institute of Technology, Cambridge, Mass. *Radioactivity and Nuclear Physics:* R. R. Palmer, Beloit College, Beloit, Wis.

Opportunity Unlimited—Some Observations About Tomorrow

By HOWARD E. FRITZ

Vice President in Charge of Research, B. F. Goodrich Company

In a final Doctor's oral examination, I was asked why I had returned to school to acquire the Doctor's Degree. I answered, "To insure a larger income," and promptly flunked. I was told later that the proper answer was, "To broaden my horizon." I was talking about a different horizon. Mine was the financial, their's the great blue yonder. I finally came to the conclusion that the more arguments won, the fewer friends there were, so I lost this one and passed the exam later. That is a pretty good lesson in psychology for all, because by losing one battle, we do not necessarily lose the war.

Later, it was brought forcefully to mind that there is a small minority of people who work diligently without regard for the needs of humanity or ultimate financial rewards. These people are usually termed *Fundamental Scientists* who dig into nature's crust for more information and knowledge relative to the natural laws, the Researchers. They are really your partners, for they very often push back the veil of ignorance a little farther and a whole new world stands before them and their partners, the *Applied Scientists.* You fellows fit into this last group, for your job will be to search for things pertaining to human needs. You will take the basic information and really go places with it.

Philosophers of an earlier day would be astounded to see that it has been business people, not the social reformers who have condemned and destroyed the status quo. .This is not to deny that scientific discovery is the raw material of our advances, yet science alone, invention alone, could not have accomplished all this. It had to be brought down from the clouds to join the service of men and women through industrial development. If we are to continue our rate of progress, we are going to need lots of bright, young people coming into business for the years hence.

Research without interest from the applied people is pretty drab. There is no stimulus to a researcher as valuable and inspiring as an expression of interest from the commercial divisions.

Think of the marvelous machines, processes and products and, as a matter of fact, civilizations, created through the application of the fundamental laws.

We are standing at the limitless frontiers of thinking: power, electronics, chemistry, metallurgy and engineering—all these sciences that are giving us the power and ability to dig into the crust of nature and wrest her secrets from her. Research is the challenge of the times; science is the new competitive weapon. It is the typically American answer to providing more jobs and better things.

The future of our civilization depends upon the ability of our engineers and scientists to disseminate information representing the true technological facts, thus promoting a better understanding of the role and the place of science and technology in our national life. It could be that some of us may live to see the day when a nation's true wealth will be measured in terms of its men and women

of science rather than in terms of its natural resources.

May I caution you that this world is not filled with nice people. It is a fact that as many people go to a contest to see the champion get knocked out as to see him win. Bob Fitzsimmons, the one-time heavy-weight champion of the world, was heard to say: "There are only two kinds of people on earth—Fighters and Quitters." There may be something to that remark when analyzed basically: Those who won't be beaten no matter what the obstacle, and those whose life is one series of hard luck episodes after another. One gains more experience and courage out of a good whipping from a champion than he does in any victories over mediocre opposition. This is just another way of saying that your early failures should be considered in the light of valuable assets for future undertakings. But if you permit past mistakes and failures to fill you with fear, a grudge against the world and loss of confidence and initiative, you will surely strike out the next time the chips are down.

You could get yourself into the same frame of mind as the cannibal who, just after the jungle party dinner said, "I get so fed up with people sometimes."

Research is Both Constructive and Destructive Force

To better assess the tomorrows, let us dwell a bit on past accomplishments.

It does not require much study or investigation to find that research is the greatest constructive as well as the most destructive force that mankind possesses and controls, bar nothing.

This destructive force is very real. There is no force which can be as deadly to an established business as industrial research. No war, no panic, no bank failure can so completely and irrevocably destroy a business as a new and better product in the hands of a competitor.

The history of modern business is packed with instances where a well-established, well-managed, conservative business has gone into bankruptcy or disastrous reorganization because a competitor has entered the market with a new or better product. Here are a few cases in point:

"In 1850 there were over 2500 miles of canals completed or under construction in the United States. Nearly a thousand additional miles were projected . . . over 150 million dollars had already been invested in this business. In terms of national wealth, this presented a proportionate investment equal to an expenditure of approximately seven to eight billion dollars at the present time. . . .

"In spite of all arguments in 1860 the canal was dying. . . . The total loss to the states was over a quarter of a billion dollars. . . . The indirect loss was surely much greater as the default of the canal bonds was one of the causes of the Panic of 1856.

The railroads came and prospered, and in 1910 the railroad executives said, "Now we have a prefectly safe business. No outside competition can touch us; all we have to do is to sell more bonds, build more railroads, collect more profits. There can be no competition to a railroad except another railroad; The experience of the canals proved that. . . .

"Now, of course, in 1910 our railroad executive was aware that some 'crackpot' mechanic, out in the Middlewest, had invented a gadget called the automobile. Being a sporting fellow, and interested in all things mechanical, our railroad executive owned one himself. Occasionally he even attempted to drive down town with it on a Sunday afternoon when he had lots of time, that is, if the weather was favorable. But to imagine that these monstrosities would ever compete with the pullman car was as absurd as that fool report that two bicycle repairmen out in Dayton had learned how to fly. . . .

"In 1910 the market value of the stock of all-American Railroads was 8.3 billions and the value of the bonds about

12.0 billions—20.3 billions total. . . . Yet in 1940. . . . The market value of the railroad bonds was less than 8 billions, and our railroad executive. . . . Could have bought on the open market the complete stock ownership of the American Railroads for 2.2 billions of dollars." 10.2 billions. Technological loss approximately 10 billions.

The technological loss is directly chargeable to the research laboratory, or more fairly, to the management which failed to insure against this loss.

The railroad and canal industries are not isolated cases. There is hardly an industry which does not afford illustrations of the destructive power of research. The cotton industry, for example, where synthetic fibers (rayons, nylon, etc.) are to a large extent chargeable with the economic loss represented by the distress of the cotton industry; the whale-oil industry replaced by coal oil, replaced by gas lighting, replaced by incandescent lights, replaced by fluorescent lighting. The old solid truck tire is gone, replaced by heavy-duty pneumatics; water-dispersible paints are here to stay; fast-drying lacquers lowered the cost of automobile finishes—all representing a loss to someone. Signs on the present horizon—Television Vs. The Movies.

This is the law of research: "Every new product produces wealth greater than it destroys." For the human need or desire which made it possible for the new to displace the old gives to the new a greater market than the old ever enjoyed.

Let us always remember that there is nothing so perishable as an established product, and that stupidity and pessimism are no defense against the impact of a new idea.

The frontiersmen who settled this, your country, risked their lives in the winning of it from the untamed forces of the wilderness. You and I are the frontiers-people of today and the frontier of today is just as ruthless, but different in that the big advances are to be made through the frontiers of thinking. Our country was founded by men and women who turned their backs on the past and placed their faith in tomorrow. Our industrial strength today is the result of that faith which has existed throughout the years in plowing back portions of today's earnings in order to insure tomorrow's opportunity.

New pursuits always involve new risks. New ventures are full of uncertainty, but the American process has always been to face boldly the risk and uncertainty and to direct a course though freedom to prosperity. Remember, you cannot steal second base and keep your foot on first base. Free men, given opportunity, make their own security, for as long as they are free the game is worth the candle and they can afford to try and try again until they succeed.

Here, then, in science and research is insurance for all of us, insurance not only good for now—it is good for all time, because the free and fertile mind, through research and development, creates more employment, more security, and higher standards than any known process.

This is the only kind of insurance that will sustain us as free people and perpetuate the process of liberty in the great competitive race for survival among nations.

Today's Frontiers of Thinking

What are today's frontiers of thinking? Here are some of them:

(a) Artificial rain-making—Not sure about validity of making rain, but artificial snow-making sure. The great snowfall in California in 1951 was a seeded storm. A great boon to irrigation where run-off water is involved.

(b) Utilization of solar energy. This must be done. We have only 300 years to go before we are out of all kinds of fuel presently commercial. Energy from

the sun is about equivalent to 1 Hp per square yard. The sun's rays shining on a single square mile of earth's surface have energy equivalent to that of one atom bomb of the type exploded at Hiroshima and Nagasaki.

(c) Guided missiles and rockets. They are here today to stay and are already staggering us with problems for new and better materials for the speeds and temperatures which will prevail in their use.

(d) Electronics and the electron. We are in the midst of a push-button and electronic era. The electron which is a unit of bouncing, darting electricity, which man is able to control, has wrought spectacular changes in the everyday life of everybody. It makes possible individual two-way radio systems, has sharpened our five senses, given us television and the electric eye. Science is on the march. This is only an index of what is to come.

(e) Viracides—One of our own products, beta-propiolactone, shows great promise as a viracide; could be that we shall help solve the problem of the common cold and influenza. Looks very good.

(f) Titanium—A light, tough and corrosion-resisting metal. One ingot of titanium at $7.50 per pound costs more than a cadillac automobile. Sheets and strips of the silvery gray metal are selling for $30,000 per ton. Yet industry is begging for more of it.

(g) Atomic energy—The splitting of the atoms of uranium 235 has been used to convert the abundant uranium 238 to plutonium for chain reactions, but the amount of fissionable material produced (plutonium) has always been less than that used and the primary uranium 235 was therefore eventually used up. The conclusion in our time of breeding experiments would make it possible to produce from fertile materials more fuel than is used. Thus, natural uranium would become, in effect, additional sources of fuel for the nuclear reactor.

Just this past week at a meeting of the national conference board in New York, it was announced that the breeder reactor was now an assured fact. This great discovery will now provide society with additional sources of energy, twenty times that of our known oil and coal reserves.

The use of radioactive isotopes poses two very serious problems to those who may be privileged to work with them:

1) The fear that they may become sterile.

2) The worry that they will *not* become sterile.

(h) The hydrogen or "Hell" bomb. No peace-time use has as yet been conceived for this development. In any event it has far-reaching implications as regards the social problems of nations.

However, if science and research can devise methods of controlling this thermonuclear reaction, the fuel and energy requirements of man can be satisfied for many, many centuries.

(i) Space travel and the earth satellite —Collier's issues for March and October, 1952. The amazing thing here is that these things relative to space travel are in the cards and fully feasible. The comic books of 16 to 20 years ago have hit the jackpot.

Not long ago, a young test pilot named William Bridgeman made history. In a needle-nosed 40-foot long rocket-powered plane, he reached the incredible altitude of 79,494 feet (about 15 miles) above the earth's surface while traveling at twice the speed of sound—1238 miles per hour. I am proud to tell you that it is my privilege to know this young man well. We have exchanged views on many subjects together.

Bill Bridgeman at that time had flown higher and faster than any human. At an altitude of 79,494 feet, for all practical purposes, 96% of the earth's atmosphere was below him. He had actually reached the borders of space. The flight though it lasted only a few minutes,

marked one more advance in man's progress toward conquering space.

As a result of this flight, another experimental plane capable of reaching an altitude of 200,000 feet (about 37 miles) and with a speed of 1800 miles per hour is being built, according to a recent announcement.

Many lives will be sacrificed in this effort, just as for the steam engine, electric motor, the railroads and airplane.

The subject of space travel has been termed "Crossing the Last Frontier." With this I disagree, because before we get out of this great problem, we will find ourselves in another still more difficult one. I am only saying there is no last frontier.

Our engineers and scientists feel that they know how to build and operate a station in space that would circle the earth at a speed of 4.4 miles per second, 15,840 miles per hour, around the earth once every two hours, and 1075 miles up. The job would take 10 years and cost twice as much as the atom bomb ($4,000,000,000). The peculiar feature of this undertaking is that it would not use atomic energy in the project. At an altitude of 1075 miles, outside the influence of earth's gravity, everything would be weightless including men and women (a brand new reducing formula) so everything would float in space. There is no air to provide oxygen or carry sound. All people would work in pressurized space suits, provided with small rocket motors, and have a safety line secured to the space station. Fantastic, but a potential reality.

Thirty years ago all of these things were given little or no place in our thinking. Today some of them constitute a highly desirable volume of sales and profit. Yesterday's products of research and development. Perhaps I have left you in a state of confusion, but I am no more guilty than the professor who had taken his students all through the texts in their four-year medical course. At graduation time he called them together and said, "Now that you have finished your course, I want to tell you one thing more. Half of all I have taught is wrong, but the trouble is I don't know which half."

This is probably true of most of the "knowledge" that we accumulate in the course of our formal aducation. From thereon, our true education begins—To unlearn the wrong half.

Challenges of Tomorrow Are Staggering

The people who make this economy tick, as I have said before, are our scientists—Your Partners—and we all are proud of them and their accomplishments. Many times in history you and they together have materially lessened the burdens of mankind, helped create a new and better civilization and contributed to the dignity and well-being of this great country.

Recent studies indicate that the total population of the United States by 1960 would be 174 million people, an increase of about 15 per cent from 1950. This population increase will be mainly an addition to the consuming group rather than to the producing group. Those at work will be faced with the task of supporting a much larger number of people than in any previous period in our history.

But in achieving more productivity, every American worker must be provided with more effective tools. These tools will cost an enormous amount of money—$200 billion worth. Compare this with the $71 billion spent for new plants and equipment in the 1920's, or with the $110 billion invested by industry in the 1940's when this country built an undreamed of productive capacity for war and peace.

An increase in population is not necessarily a stimulant to business. Today, more people in India and China might simply lead to more starvation.

But the situation in the United States is quite different. With our competitive economy, our abundant natural resources, our technical facilities, and our substan-

tial "know-how" for producing goods and services, increases in population can exert a stimulating effect on business. These are some of the new and limitless horizons.

The challenges of tomorrow are staggering. The cloak of complacency, if any, must be discarded. Ingenuity, resourcefulness and persistence must be our watch words.

To survive, grow and prosper, we must recognize and dispose of these responsibilities:

1. If we expect to better our situation in the future, let alone feeding, financing and rebuilding the rest of the world, we must contribute the necessary new and better things to keep every mill, every mine and every farm turning out useful and needed products. Because products, not dollars, are wealth.

2. The new things to come have been splashed across the pages of newspapers and magazines and broadcast over radio and TV, dangerous and exaggerated to be sure, but many of them are here now and there are many more over the horizon. We must have our just share of these innovations and we will only get them by an all-out team effort of cooperation and determination.

They could be fabulous.

3. If there is any one thing we must reckon with it is the fact that we will be in a constant state of constructive change. The American people have gotten into the habit of expecting more for less and in the end they always get it. If we are prepared for and tolerant to the changes that must come to our products and processes, we will meet these challenges head on and emerge with a whole skin.

4. Cracking the crust of nature for new knowledge and new ideas is a difficult, tedious and discouraging process. But if we can continue to have your support and encouragement, progress will be made, and, as I see it, the future will be a good place in which to live.

To me the most satisfying reward in this life is the joy of accomplishment, and accomplishment can best be attained through the efforts of a great, well—integrated society—all of us together.

Let us pledge ourselves here and now to keep the fires of creative research burning and the wheel of prosperity and plenty spinning in our time.

In the News

The Institute of Statistics at **North Carolina State College** is sponsoring a nine day intensive training program in Statistical Methods for Research Workers in Industry and the Physical Sciences starting January 22, 1955 and running daily (including Sundays) through January 30, 1955. The course is designed to make available to research workers in industry and the physical sciences the new and powerful statistical techniques of data analysis and experimental design. Guest lecturers will include W. J. Youden, Statistical Engineering Laboratory, National Bureau of Standards; Carl A. Bennett, Hanford Works, General Electric Company; and Cuthbert Daniel, Statistical Consultant, New York City.

A registration fee of $100.00 will be charged and enrollment will be limited to the first fifty qualified applicants. For further information write to Institute of Statistics, North Carolina State College, Box 5457, Raleigh, North Carolina.

The Importance of Dependable Approximation Methods in Nuclear Engineering*

By CHARLES F. BONILLA

Professor of Chemical Engineering, Columbia University

It is now evident that continued progress towards economical nuclear power will require many new concepts, variations, and improvements in reactors, along with the painstaking computations necessary to check that no part is overheated nor overstressed. Although physicists and mathematicians have done much of such work to date, as their interest passes on and as more engineers become familiar with the field, the burden of these designs and consequently the advancement of nuclear power falls more heavily on the engineers' shoulders.

Rough data and approximate methods are characteristic of the field at present, as witness the uncertainty in many nuclear cross-section values, the one-group neutron diffusion theory, and the unreliability of most shielding and thermal stress calculations. However, these instances are approximations which had to be obtained so that design could go on.

The young engineer entering this field will soon learn and appreciate these specific procedures, but in general he is not taught to use nor, in particular, to originate approximate methods on account of the emphasis on precision and elegance in our mathematics, physical science, and engineering courses. I therefore wish to emphasize that approximation methods should be duly included wherever appropriate in the courses in engineering curricula, and certainly for engineers going into the nuclear field. These

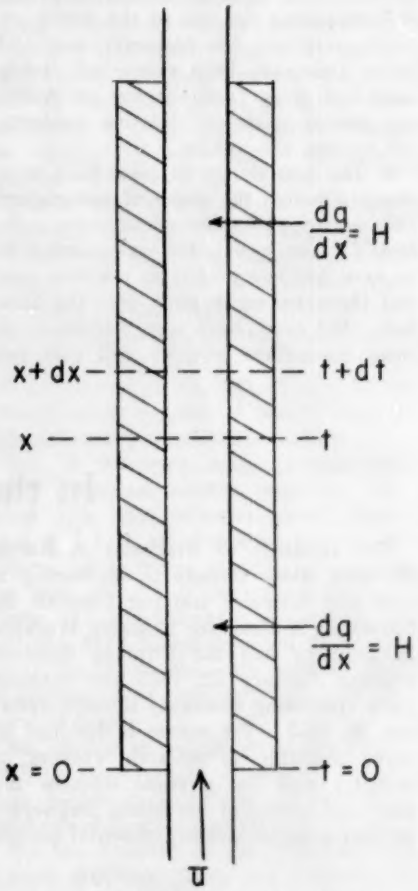

FIG. 1. Coolant flow through metal with heat generation.

* Presented at the Preliminary Conference, Summer Institute on Nuclear Science in Engineering Education, Columbia University, April 24, 1954. Contribution No. 47 from the Chemical Engineering Laboratories, Engineering Center, Columbia University.

methods include, in general, graphical and numerical integration of differential equations, and in particular incremental and relaxation methods for the solution of steady and unsteady state problems in fluid flow, heat transfer, neutron diffusion, gamma ray generation and absorption, stress and strain computation, etc. An exhaustive list of such methods will not be provided here—a word to the wise is sufficient, as each teacher is well able to dig out and present such methods if he is made aware of their practical importance. Instead, an example in which such a method proved valuable in reactor design will be outlined.

Example

Assume a channel filled with liquid metal coolant in a nuclear reactor at temperature $t = 0$. At time $\theta = 0$ coolant flow at $t = 0$ is suddenly started and the surrounding metal begins simultaneously to generate heat at constant rate H per unit length. It is desired to find the temperature history along the channel, for stress calculations. L/D is large and for simplicity it may be assumed that at any distance x along the channel from the inlet the temperature in the liquid metal coolant and cooled solid metal is uniform at t. The situation is as shown in Fig. 1. The heat capacity of the solid per unit length may be designated m_s and of the coolant m_c, and the coolant average linear velocity $\bar{u}$.

When flow starts up it will take some time (call it θ_1) for the coolant that was not initially in the channel to first reach any position x. Evidently

$$\theta_1 = x/\bar{u}. \tag{1}$$

Before time θ_1 all of the coolant to pass x was in the reactor (and thus being heated) all the time since $\theta = 0$. After θ_1 the coolant passing x was *not* in the reactor (and being heated) all of the time since $\theta = 0$. Thus a change in slope of t vs. θ seems reasonable when θ_1 is reached at any location.

Before θ_1 a heat balance yields

$$H\theta = (m_s + m_c)t. \tag{2}$$

At infinite time a steady state will have been reached such that

$$Hx = \bar{u}m_c t_\infty. \tag{3}$$

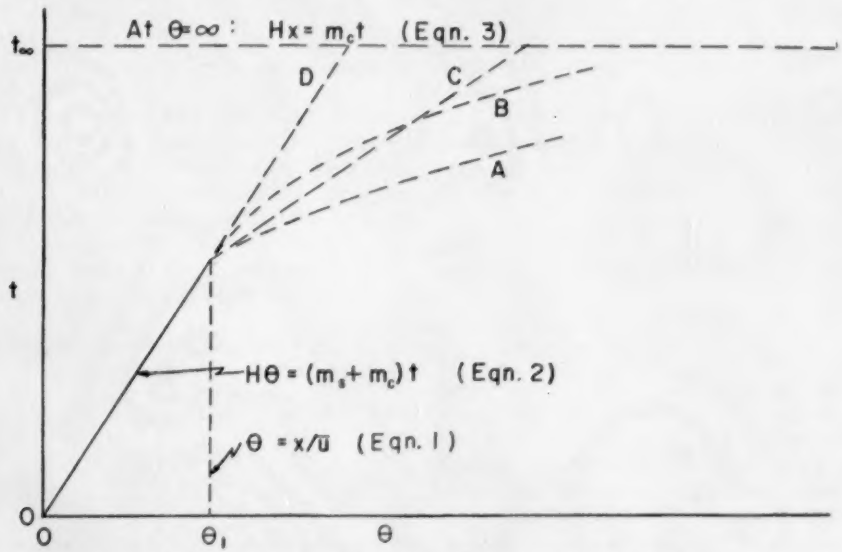

FIG. 2. Temperature variation with time at position x.

TABLE I

CALCULATIONS FOR REACTOR START-UP

θ / $x\rightarrow$	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	0	0	0	0	0	0	0	0							
1	0	20	20	20	20	20	20	20							
2	0	30	40	40	40	40	40	40							
3	0	35	55	60	60	60	60	60							
4	0	37.5	65	77.5	80	80	80	80							
5	0	38.75	71.25	91.25	98.75	100	100	100							
6	0	39.38	75.	101.25	115.	119.38	120	120							
7	0	39.69	77.19	108.13	128.13	137.19	139.69	140							
8	0	39.84	78.44	112.66	138.13	152.66	158.44	159.85							
9	0	39.92	79.14	115.55	145.39										
10	0	39.96	79.53	117.35	150.47	175.39									
11	0	39.98	79.74	118.44	153.91	182.93									
12	0	39.99	79.86	119.09	156.18	188.42	212.93								
13	0	39.99	79.93	119.47	157.63	192.30	220.67								
14	0	40.	79.96	119.70	158.55	194.97	226.49	250.67							
15	0	40.	79.98	119.83	159.12	196.76	230.73	258.58							
16			79.99	119.91	159.48	197.94	233.74	264.66	288.58						
17				119.95	159.69	198.71	235.84	269.20	296.62						
18					159.82	199.20	237.28	272.52	302.91	326.62					
19						199.51	238.24	274.90	307.71	334.76					
20							238.87	276.57	311.31	341.24	364.76				
21								277.72	313.94	346.27	373.00				
22									315.83	350.11	379.63	403.00			
23										352.97	384.87	411.32			
24											388.92	418.09	441.32		
25												423.51	449.70		
26													456.60	479.7	
27														488.15	
28															518.19

These three equations are shown on Fig. 2. The intermediate portion connecting equations 2 and 3 remains to be determined. Four possibilities A, B, C, and D are qualitatively shown.

For the intermediate period, a heat balance yields the differential equation

$$H = (m_s + m_c)\frac{\partial t}{\partial \theta} + \bar{a}m_c\frac{\partial t}{\partial x}. \quad (4)$$

The engineers working on this problem were not able to obtain any direct solution of equation 4 by the usual methods of calculus and differential equations (however, it can be solved by operational calculus). One difficulty is that only one boundary condition is clear-cut, namely, that when $\theta = \theta_1$ by equation 1, $t = H\theta_1/(m_s + m_c)$ by equation 2. The slope of the intermediate position is not definitely known at θ_1 and neither the slope nor θ is definitely known at t_∞. It may be noted that equation 2 (line D in Fig. 2) obeys equation 4, but seems to be a trivial solution, since it gives $(\partial t/\partial x) = 0$, which is clearly incorrect by equation 3.

The only method of solving equation 4 that was hit upon yielded the line

$$H(\theta - \theta_1) = (2m_c + m_s) \times \left[t - \frac{t_\infty}{1 + \frac{m_s}{m_c}}\right]. \quad (5)$$

This is similar to line C, Fig. 2, and satisfies the intuition that a change in slope

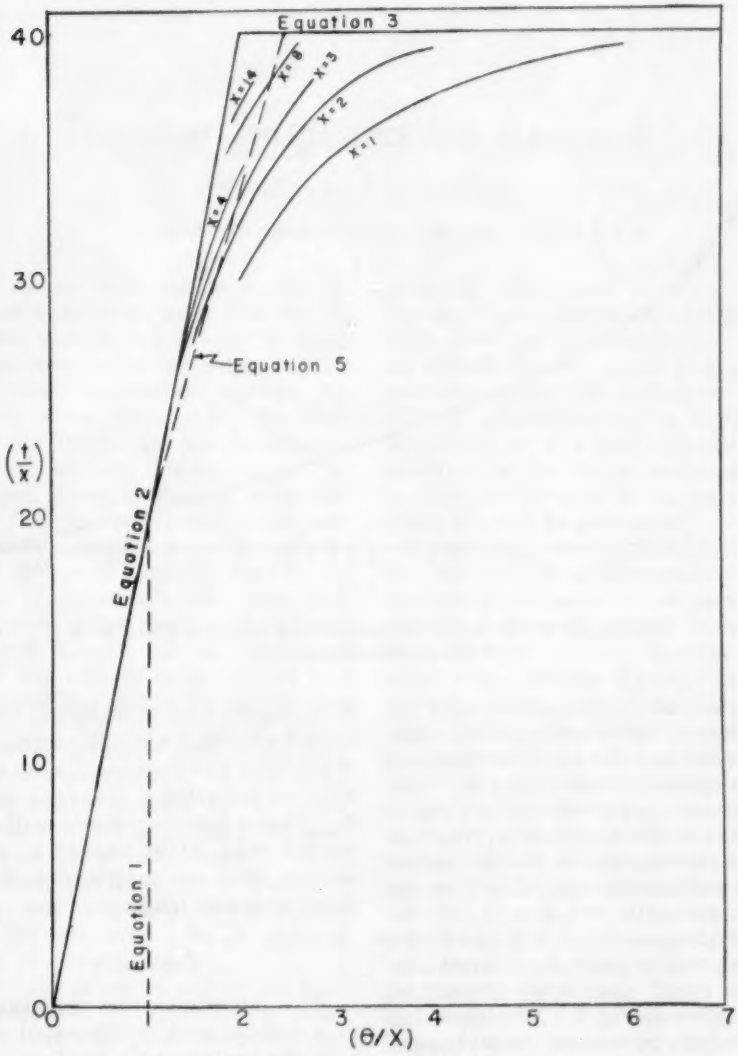

FIG. 3. Generalized plot of specific illustration of reactor start-up.

should occur at θ. (At the time it was not noticed that equation 5 with θ_1 and t_∞ replaced by equations 1 and 3 does not quite satisfy equation 4.) However, the solution was not entirely convincing, and a finite increments solution was employed as a check.

This problem was worked for the following numerical values: $\Delta x = 1$, $\bar{u} = 1$, $\Delta\theta = 1$, $H = 10$, $m_s = 0.25$, $m_e = 0.25$. The selected sequence of events was:

a) During each $\Delta\theta$ the fluid is stationary, and fluid and solid heat up by $\Delta t = H/(m_s + m_e) = 20$.

b) Between intervals the fluid suddenly moves the distance Δx adiabatically, then the solid and liquid temperatures equalize.

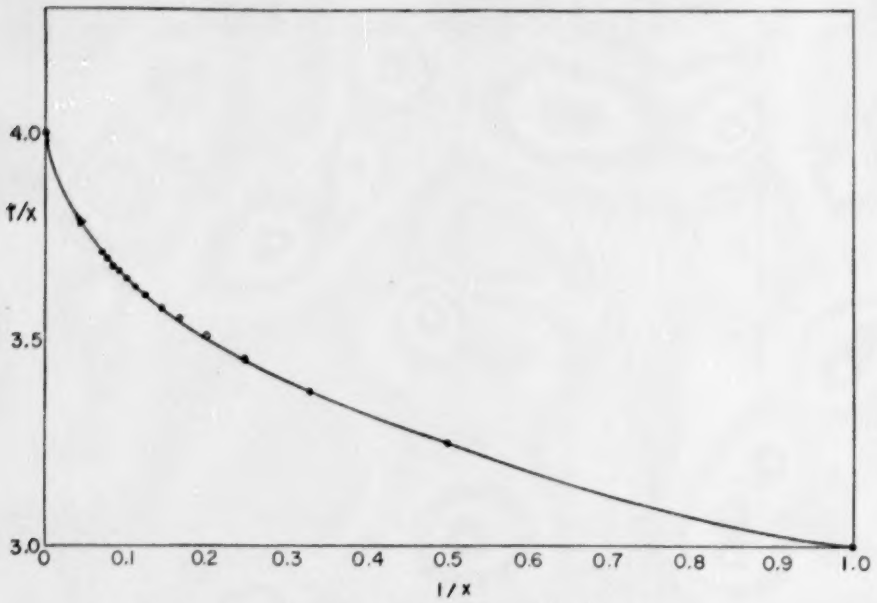

FIG. 4. Extrapolation of temperature rise at $\theta/x = 2$ to $x = \infty$ for the specific example.

For each $\Delta\theta$ the process in each Δx thus consists of averaging the solid temperature and the adjacent upstream liquid temperature and adding 20. The numbers obtained are shown in Table I. The process was simplified by the fact that the temperatures at $x = 2\theta$ (underlined) are obtainable by adding 30 to the temperatures at $(x - 1, \theta - 1)$.

By dividing equations 1, 2 and 3 by x it is seen that a generalized solution in terms of (t/x) and (θ/x) is possible. This is shown in Fig. 3. The increasing numbers of increments thus become closer and closer approximations to the exact solution, with an infinite number of increments for a finite case, or infinitesimal values of $\Delta\theta$ and Δx. Curves obtained for up to 14 increments of x are shown in Fig. 3. Figure 4 extrapolates (t/x) at $(\theta/x) = 2$ to $1/x = 0$ or $x = \infty$. It is evident from these figures that the correct solution is a straight continuation of equation 2 to equation 3, even though intuition indicated a change in slope at θ_1. Thus a finite increments method has yielded with little trouble a reliable answer when an analytical and intuitional approach failed.

Conclusion

It is my opinion that most engineers on a problem such as this would employ only the analytical approach, would be uncertain of the best attack, and after considerable effort would not obtain the correct result; whereas with only a small amount of training in approximation methods they would have encountered no difficulty.

Training Engineers for Research*

By CHARLES E. BALLEISEN

Southwest Research Institute, San Antonio, Texas

Whether we train engineers for research or whether we select them for it, I am not certain, but I want to point out right here at the beginning that we should train engineering students for Research, or for Sales, or for Manufacture, or for Design, and not for automotive work, aircraft, transportation, refrigeration, power production, or similar trades. We must realize that, in the past few decades, engineering has lost a great deal of its former empirical nature. At the turn of the century, fifty years ago, the engineer worked largely from handbooks and tables, and the theoretical scientist was engaged in finding out how the engineer was able to do what he did. A quick eye for the factor of safety made all the difference between the good and the poor practitioner. In such times it was necessary to know all the tricks of the trade. It was necessary to have in mind all the previous ways in which the problem had been solved, for these solutions had been made by chance, and not in the cool, gray light of scientific analysis or deduction.

Today, the factor of safety has been largely replaced by experimental stress analysis, the theory of statistics, and higher mathematics, but our engineering training is still designed largely along craft lines.

To spare embarrassment among my listeners, I will not bear down on the horrible examples where the students' time is taken by memorizing catalog types rather than by memorizing basic principles. This would be less serious if a young man could forecast his employment accurately and remain with it for the rest of his life. Some few do, but the vast majority will work in five or ten different industries, or at least, different companies. It is a rare individual who spends all of his life in the industry of his first job, or even in the course and option in which he graduated!

It has been my further observation that the types of activity engaged in by engineering graduates do not correspond with the customary, civil, mechanical, electrical, and chemical divisions, but rather with a division roughly into sales, research, design, production, and operation. These latter divisions involve human personalities and aptitudes; the former ones assume the learning of specific names and numbers.

Let me recite an example. I once worked with an industry which proudly boasted that it had no experimental department as such. It had an engineering department, and the engineering department handled all work involving design changes or innovations. The result was utter mediocrity at all levels. A call for a new product would stir reminiscences that shop tooling must be maintained without changes, while the making of a minor change to facilitate production would be delayed while the engineer attempted to work in all the little improvements that he had in mind and had been waiting to drop into the production model. As I have said, the end result was mediocrity, confusion, and frustration. How much more could have been accomplished had the research and de-

* Presented at the Annual Southwest Section Meeting of ASEE, University of Texas, April, 1954.

velopment problems been separated from the production problems, and both from maintenance problems?

Timeless Principles

I hope this little example will bring out that the technical graduate needs a good and thorough grounding in fundamentals of a science, and he does not need to learn in school those practical tricks that are applicable to a particular industry. Time does not permit this luxury. This evil is further enhanced when we recall that it is not possible to keep our textbooks or exhibit collections up to date, nor anywhere near complete. At our best, we must show the student old examples and limited ones. Let us better use our time to show him fundamental, universal, and timeless principles, which he can apply all through his life, regardless of job changes.

This diatribe, while general, is particularly applicable to those students who will go into research. The Armour Research Foundation has stated that, in selecting employees, it searches, not so much for what the man knows, but for what he can learn. The good researcher must exist in a state of educated ignorance and curiosity.

An excellent paper on this subject appeared by W. L. Everitt in the Journal of Engineering Education in December 1951. In it, he developed the following seven objectives of engineering training, which I feel should be called to your attention at this time. They are:

1. Knowledge and appreciation of history
2. Formulation of problems
3. Collection of information
4. Distinguishing the revelant from the irrelevant
5. Non-quantitative evaluation—particularly a companion of numerical analysis
6. Translation of analysis into conclusions which are then reduced to specific recommendations
7. Oral and written presentations in a form designed to accomplish a clearly perceived, practical purpose.

Reduced to absolute fundamentals, Everitt said it was the purpose of engineering education to:

1. Teach Fundamentals
2. Teach to Think
3. Teach to Achieve Action

Note that no limitation of field of application is placed here.

Time places many limitations on what we would like to impart to our successors. Time is limited by their urge and desire to enter life and also to secure economic independence. As educators, it is our duty to impart to them that which they cannot secure outside of the university, and that is fundamentals—fundamental knowledge, in as detailed and as thorough a manner as possible. Remember, applications and interests will change and can be learned on the job, but only in the university do the economic conditions and the proper atmosphere exist for thorough, continued, and repeated drill in basic scientific and engineering fundamentals!

The average graduated research worker is not an outstanding genius. He is usually a slow, and thorough man. He is a man who has enough education and training to recognize his problem and to develop its leads, but he is not so learned that he rejects the help of others. The day of the ivory tower is past. I can tell you again of watching one of my associates, a biologist, develop into a research team. His first assistant was a photographer, to record the specimens; then came a physiologist, to deduce the reactions in question; a pharmacist, to prepare the necessary chemicals, and a statistician, to plan, to refine, and to analyze the experiments for artifacts and random influences and levels of significance. Today's researcher must ask questions, not only of himself and his books, but also of others. He must be a sociable person, for he works in fields which have not been tilled before, and he needs help

in removing the rocks and digging out the stumps which must be done before straight furrows may be plowed.

Virtues of Collaboration

I cannot emphasize too much that the research worker must be ignorant, he must be inquiring, he must never decide that he has all the answers and that others cannot be helpful. The fields of knowledge today are too deep and too complex for one man to navigate alone. Further, we must give some credit to our ancestors. They were not entirely knuckleheads, and they have solved all the easy problems by now. Today, we must progress through teamwork. Therefore, teach your young men the virtues of collaboration.

I have earlier stressed the necessity of thorough training in fundamentals. The research worker needs to know the existance of all fields. He needs to know when to call in a stress analyst, a microwave specialist, a surface chemist, a statistician, a photographer, a writer, a lawyer, or other consultant. I agree that there is a limit to what can be covered in college, but we must spend some time in telling of the other fields in order that the new worker may realize his limitations and also realize that these limitations can be broken by help from the right people. Within these many fields, he must find one specialty, and he must work that specialty to death. He must know its history, the story of its early pitfalls and false hypotheses, of caloric and of phlogiston. In this field, he should know the alternate methods, the short cuts, and the present applications. Here, alone, I will relax my strict rule against memorizing the hardware of the art. In the prime specialty, knowledge of the hardware is essential, but it should be gained in practical work and not at the earlier expense of theory. Our good researcher will now also learn what is not there. He will see the missing links and know the uncharted areas and he may even find out why those areas have been avoided by the earlier workers. Perhaps they have just been overlooked, or perhaps they are the real "stinkers." Many a man has been caught in a research project because he did not realize that the project he undertook had remained unsolved because of some minute, but inherent difficulty. In short, develop your research man to browse and to dream a little, or as Bacon said, "to weigh and consider."

Perhaps by now, I have spoken too much—I have spoken in parables and confusion. I have advised specialization, without losing sight of collateral objectives. I advise theory, and practical applications; I advise deep learning, and a curious ignorance. I plead for the man who has the courage and the confidence to go it alone, and I advise him to consult with others always. But above all, I counsel a thorough knowledge of scientific fundamentals and a fierce desire never to age, but to keep young through the curious investigation and acquisition of new knowledge throughout life.

Mid-Winter Meeting of Engineering Drawing Division

Time: January 27, 28, 29, 1955

Place: University of Tennessee, Knoxville, Tenn.

A three day session of technical programs and inspection trips which will include technical papers and panel discussions by teachers of engineering drawing and men from industry. Inspection trips will include the Oak Ridge National Laboratories and Great Smoky Mountain National Park. Detailed programs will be mailed to members of the Engineering Drawing Division.

Basic Science and Design in Soil Mechanics*

By HOWARD P. HALL

Associate Professor of Civil Engineering, Northwestern University

Statement of the Problem

The occasion for this paper is a panel discussion whose theme is the effect of the recommendations of the Engineering Evaluation Committee on courses in soil mechanics and transportation, with particular reference to the relation that those subjects may bear to a broad engineering curriculum of the kind identified in the Committee Report as professional-scientific. I have chosen to treat the subject at hand by suggesting some fundamental strategy that could be applied to an entire curriculum, and showing how such an approach would work out in the case of undergraduate instruction in soil mechanics.

The situation that requires attention, familiar enough to need no detailed description, is the lack of sufficient time in a normal four-year curriculum to treat all the subject matter that most of us consider important, to the extent that we consider adequate, and within the framework of the present conventional breakdown of subjects.

I do not consider lengthening the curriculum to be a satisfactory solution. In my opinion, to go to a five-year curriculum now would only hasten the day when agitation would begin to make it six; and so on without end. The fallacy in this approach, I think, is the implication that something is being completed in this period, and that it now takes longer to complete it than it used to. I think we find that any end we think we see in this case is a mirage: We may move toward it, but it doesn't seem to get any closer, and we finally succumb to disappointment, frustration—and an even longer curriculum.

Briefly, then, while I do not suggest that there is any magic in the number four, I think that four years is enough time for a capable young man to spend as an unproductive learner at whatever his chosen calling may be. Thus, the real challenge to us is to build an adequate foundation in the four years that we now have.

Analysis

The objective of a program of education in engineering is of course to develop the qualifications that a competent engineer should have. From a technical standpoint, facility in design appears to be among the foremost of these qualifications, and to be as well the function that distinguishes an engineer more sharply than any other single feature from other practitioners in science. The term design is used here in what I understand to be its accepted sense, that is, the origination of a machine, structure, or system. A design need not be the first of its kind, although it frequently is in part. It need not serve a useful purpose, but exceptions of this kind are trivial. And of course, it need not even work, since that consideration only introduces the quality of the design. Essentially, it is necessary only that the specific machine or structure or system not have been available before.

There is one important restriction that should perhaps be made in considering

* Presented at the Annual Meeting, ASEE, Civil Engineering Section, University of Illinois, June, 1954.

design as a distinguishing function of an engineer, and that is that it is understood to be directed down scientific channels. An architect, by contrast, is a designer; but to the extent that his design is concerned with aesthetic considerations, his work is not engineering.[1] This introduces what I take to be the second major qualification of an engineer, namely a background of basic science. However, to imply, as I have, that a background of basic science is prerequisite to competent design is to invite protests from those who have known excellent designers who had had no formal education and who appeared to have no organized understanding of basic science. My conception of the appropriate answer to these protests follows.

Theory and Experience

It would be well to note parenthetically at this point that in advocating a thorough grounding in basic science I am in effect expressing a preference for what has been labelled professional-scientific as distinct from professional-general, and am applying that preference to any curriculum that is to be specifically identified as some kind of engineering.

To return to the question of the importance of a background of basic science to design and therefore to engineering, we may note at the outset that competent design pre-supposes a combination of some degree of knowledge of how the materials and other elements in question will behave and sufficient judgment to recognize and make suitable allowance for the gaps in that knowledge. This vital factor of judgment comes primarily from experience, but it seems to me that even the widest experience can contribute effectively to the development of judgment only through the evaluation of that experience against the theoretical scientific background from which it constitutes a continuous deviation. Many able engineers have discarded theory to varying degrees; but none, I think, has got away with it without first having mastered the theory that he has discarded. Consequently, it may be argued with justification that he hasn't discarded theory at all, but has softened its rigor with so many modifications that its analytical tools lose their efficiency. Perhaps the real point I am making here is to stress the distinction between a misleading theory of rigorous formulas and a reliable but computationally unwieldy theory that consists of a fundamental understanding of the laws of nature. The latter, in my opinion, can never be discarded because the natural laws that make it up govern the behavior of everything on earth whether we like it or not. Our job is to untangle the threads, and those who swear by theory, as well as those who swear at it, are actually all carrying on the search for basic science in the most promising way they know.

A Proposed Solution

If we accept the premise that basic science and design should constitute the vital elements of an engineering curriculum, it follows that attention to these elements should be continuous in a curriculum, that is, that the presentation of each course should be such as to make its background in basic science clear and such as to indicate its design potentialities.

The undergraduate who has the clearest view of basic science is, I think, the one who sees it as composed of the fewest unrelated parts. The greater the number of elements that can be arranged in a patently logical sequence, the smaller the number that is left as a list to be memorized. Thus, it becomes the task of the instructor to call attention continually to the fact that the mathematics, physics, and chemistry in, let us say, soil mechanics are the same in their essence as they were when they appeared in structures, thermodynamics, or under their

[1] This is not to say that an engineer need not concern himself with aesthetic considerations.

own names. The result of such an approach is admittedly to reach no new areas of application directly; but it appears to me to have the advantage of developing greater resilience in the student's response to the unfamiliar, and therefore greater potential ability to apply principles to the unforeseeable variety of problems that cannot possibly be treated in a college curriculum.

In the case of the design element in engineering instruction, the approach that I am proposing is again one that does not add to the graduating student's collection of specifics. Here the important thing is to call attention, not simply to the fact that an observed phenomenon differs from the theoretical version, but to the areas of theory that are found wanting, to the ways in which the discrepancies appear to refute theory, to the most likely reasons why such differences occur, and to what can be done about it. Thus the student emerges, not with the impression of an irreconcilable conflict between theory and experience, but with an intelligent awareness of the shortcomings of current theory, and some idea of the directions in which he must look for information that will lead to a better understanding of the laws of nature if his own experience is ever to become something more than a mass of untutored observations that are related obscurely if at all.

Instruction in Soil Mechanics as an Illustration

I have selected soil mechanics as the subject with which to illustrate the application of the foregoing ideas partly because it is the one that I am most familiar with and, perhaps a little more urgently, because it is one of the subjects mentioned in the title of this panel. By a lucky coincidence, it also illustrates my argument very well.

Early in a course in soil mechanics the subject of clay soils, clay minerals, and some of the attempts to account for their properties and behavior may come up. It will frequently not occur to the average student at this point in a soil mechanics course that the instructor is duplicating or building directly upon something he learned in freshman chemistry or sophomore physics. If the identity can be clearly established, the student can be persuaded to accept this part of the course as essentially the retracing of steps already taken, rather than as the first faltering step into the darkness of a strange land. Thus, he realizes that the material under discussion lies at least partly in a familiar area and is not really new in the severest sense. The resulting psychological gain can sometimes be converted into the saving of some instructional time.

Mohr's Circle is identified by many undergraduates as a peculiarly frustrating part of the science of soil mechanics. Considerable advantage can be gained if the time is taken to show that Mohr's construction is simply a pictorial way of writing the equations of statics and has nothing to do with soil mechanics. Even greater advantage can of course be gained by having introduced Mohr's Circle in elementary mechanics, so that a distinct point can be made of the tie-in at the time of its introduction into the soil mechanics course.

One of the most fruitful areas for calling attention to common scientific principles is the field of flow. In soil mechanics, it is convenient to begin a discussion of seepage with Darcy's law; and more advanced treatment frequently proceeds to Laplace's equation. Yet the only appreciable prior contact the average student in a soil mechanics course has had with the flow of water has been in fluid mechanics or hydraulics courses, where Bernoulli's equation was the central theme. It will not occur to the average student to attempt to reconcile these expressions; but if their consistency with common principles is established, the misconception of a whole new science of flow, peculiar to soils, or at least to por-

ous media, is corrected, and the existence of the extent of common base understood. This revelation will sometimes encourage a student to trace this particular common element much farther afield, and in any case will leave him better prepared to cope with unusual problems that cannot be treated adequately as part of his formal education.

The shrinkage of a clay provides the soil mechanics instructor with a chance to develop in the student some measure of understanding of surface tension and capillary action—subjects of increasing importance that ordinarily get little attention in a standard curriculum.

Turning to the design element, we find that soil mechanics has a built-in feature that lends itself extraordinarily well to the presentation of this phase of the subject: The majority of natural soils are among the most inhomogeneous of all engineering materials. Not only that but the inhomogeneities are sometimes just regular enough to tempt the bold, if not the wise. As a result, it is of the greatest importance in the design of foundations and earth structures to complement theory with judgment based on experience.

The two major objectives in the design of foundations—safety against excessive settlement and safety against rupture—are ably represented in theoretical mechanics; the one in the form of a well-worked-out mathematical theory of consolidation, the other in several straightforward techniques of stress analysis. The theories are reliable if the soil is homogeneous and if the designer can evaluate the appropriate constants. To the extent that these two if's remain contrary to fact, judgment is the designer's only recourse. And the instructor who gives the impression of turning his back upon theory in such a case not only, in my opinion, misleads the student, but also misses one of the best opportunities in an engineering curriculum to trace the interaction of theory and judgment in the mind of a competent engineer. For theory is still there to give the designer at least an inkling as to what elements are important, which of them are paramount, and how each affects the answer. In fact, it cannot be other than theory, although of an informal kind, that tells even the designer-by-precedent which of the cases in his experience is the truest precedent.

Conclusion

If the argument presented in the foregoing paragraphs has any validity, it applies to any technical subject in an engineering curriculum. I have used soil mechanics to illustrate the argument, not the argument to defend the place of soil mechanics in a curriculum.

The result of the approach suggested will not necessarily be the clearing of space in a curriculum for more engineering applications—possibly even to the contrary. The result that I consider possible and desirable is the development of sufficient potential in an undergraduate to make him capable, if the occasion arises, of handling many more problems of a non-routine kind than space could ever be cleared for in a curriculum of acceptable length.

To introduce a familiar parallel in the economic field, I am suggesting that if we concentrate, in engineering curricula, on what could be called capital knowledge, which can serve a number of objectives, we shall come closer to covering the field than if we keep adding consumers' knowledge, each of whose items ordinarily serves but one purpose.

A final point in favor of the suggested approach is the consideration that efficiency is secured by making the subject matter of any course serve at least two purposes—namely, the immediate one of providing specific instruction in a particular subject, and the more far-reaching one of developing one or both of the two general requirements of a competent engineer. Furthermore, the inclusion of this material in every course removes, at least to some extent, the urgency of devoting whole courses solely to design.

A Realistic Approach to Reinforced Concrete*

Ultimate Strength Theory in a Senior Course

By PHIL M. FERGUSON

Professor of Civil Engineering, The University of Texas

Fundamentals Come First

A course must be built upon a philosophy of engineering education just as surely as must a curriculum. If it is a senior course, the appropriate philosophy may be quite similar to that governing the curriculum as a whole.

Present day curricula are gradually moving in the direction of more theory and less practice. They reflect sweeping changes in many areas, in civil engineering, for example, from hydraulics to fluid mechanics, from foundations to soil mechanics. They reflect totally new methods such as photogrammetry and radioisotopes. Incidentally, this increasing complexity of the civil engineering field raises serious problems which can scarcely be mentioned here, such as the increased need for graduate study, and the increased need for apprenticeship training which is only partially available.

Reinforced concrete is also moving in the direction of a better understanding of fundamentals. But one distinction must be made here. This is not a movement in the direction of a more mathematical treatment of the subject. Rather it is a movement in the direction of a better understanding of the physical action of reinforced concrete. Unfortunately our knowledge of the physical properties of concrete is not adequate now to support a mathematical analysis that can be projected with confidence into untested areas. This means that the better understanding of fundamentals is actually arising, and can only arise, from increased laboratory and field investigation and research.

At the same time reinforced concrete practice is, as usual, far in advance of our theory. Prestressed concrete is seeing increased usage. Thin shell barrel arch roofs and domes and spectacular folded plane or hip plate structures are becoming more common.

Thus there is pressure on a senior course in reinforced concrete from both sides—fundamental understanding and advanced applications. Under these conditions the teacher should not hesitate to leave advanced applications for graduate study and concentrate on a better student grasp of the way reinforced concrete really acts. Such an objective is not inconsistent with the necessity of informing the student of present-day specifications and present-day procedures. A school must be realistic enough to understand that its students go out into a very practical and highly competitive world that operates on the basis of present day specifications. The student should understand the basis for these specifications insofar as possible. But it is even more important that he understand some of the weak points in these specifications and have his mind opened to changes that seem to be in the making.

Ultimate Strength Theory Is Fundamental

What are some of these changes? The most probable early change seems

* Presented at the Southwest Section, ASEE, before the Architectural Engineering and Civil Engineering Divisions, April 17, 1954.

to be the adoption of ultimate strength theory for bending and for combined direct stress and bending. Ultimate strength theory is already in our column specifications, although it is somewhat disguised. Changes in our specifications for shear or diagonal tension are not many years away. And splitting, as a limitation upon bond strength, is certain to require specification changes soon.

All of these are here lumped together as various aspects of an ultimate strength theory, although this term has commonly been considered chiefly in its relation to bending or direct loading or combinations of these. A distinction must be made here between ultimate strength methods and limit design. Ultimate strength is used here to refer to the maximum strength of a given cross-section. This strength exists regardless of the size of the moment or shear or axial load destined to act on the member. It is entirely distinct from those ideas of limit design relating primarily to the favorable readjustment of moments in continuous beams or frames under overload conditions. Ultimate strength theory applies to statically determinate members as well as to indeterminate structures.

Ultimate strength theory implies that working stresses will be neglected in favor of ultimate strengths, and that working loads, moments, and shears will be increased by a load factor or load factors for design purposes. The straight line stress theory has no place in this procedure because the straight line stress distribution does not exist at ultimate strength loads.

The Senior Course Can Include Ultimate Strength

Can two such contradictory approaches as ultimate strength and straight line stress distribution be included in a single beginning course without seriously expanding it? The answer is affirmative, because we do not need to make students into experts in the area of ultimate strength. The ground rules for such design are still being formulated and may be different tomorrow. What the student needs is basic understanding, no more. At the University of Texas we have found it easy to give this general understanding, at very little cost in time.

Since 1950, the study of reinforced concrete has started, at the very beginning of the course, with ultimate strengths —how beams fail in moment. A slight change is being made this year: axially loaded column discussion is being moved ahead of beams. As thus projected, the ultimate strength elements proceed in the following fashion.

The course starts with a brief discussion of the relative strength of plain concrete in compression and tension and the need for reinforcing steel in beams and columns.

Column Tests First

Columns (without bending) are to be introduced immediately, with about one period devoted to a discussion of the extensive column tests of the early thirties. This involves recognition of inelastic factors such as shrinkage and creep (or flow) of concrete right at the start. It is pointed out that although one cannot, with any respectable accuracy, calculate actual column stresses under axial load, he can determine ultimate column capacity rather closely. The column has the combined ultimate strengths of the concrete and the steel considered separately. This is presented as a true ultimate strength theory, slightly modified in form in the specifications. The basis of the present A.C.I. column formula is explained; the negligible difference in action between a spiral and a tied column up to the yield point is emphasized, and the different factors of safety used for concrete and steel, for tied and spiral columns, are pointed out. The spiral steel requirement is related to test data. Problems with the standard A.C.I. column formula are assigned at this stage.

Beam Action and Beam Ultimate Strength

Beam theory is next introduced, again by a study of ultimate strength—how beams fail. The resisting couple in the reinforced concrete beam is discussed, with C represented as a resultant force not yet located. The moment $M = C.jd = T.jd$ is developed with standard definitions for j and d. Thus far, this could just as well be the approach for a discussion of the straight-line theory. But here the presentation changes.

The complete stress-strain curve for concrete in compression is presented next, with particular emphasis on that portion beyond the peak or maximum stress. The student is reminded that his experience in testing cylinders fits this picture—the balance beam on the mechanical testing machine (or the dial reading on the hydraulic machine) always drops well ahead of failure. The student, at the start of this discussion, is given nine pages of notes in order to permit him to give undivided attention to the lecture presentation rather than to taking notes. Unfortunately, no printed text is yet available for this treatment of the subject.

Next, the probable distribution of compressive stresses in the beam under increasing load is discussed: at small loads, triangular or straight line; at moderate or working loads, slightly curved; near ultimate load, parabolic; and at ultimate load, with extreme fiber stress less than the maximum stess, i.e., as presented by Whitney. All of this is specified to be at first loading without prior shrinkage. Reference is then made to the standard working stress (straight line) theory and some of its weaknesses, as follows:

"Although present day specifications emphasize stresses at working loads and present day calculations pretend to calculate these stresses, laboratory tests of reinforced concrete beams show that actual deformations and stresses at working loads only faintly resemble our calculated values. In other words, present day specifications and the corresponding standard calculation procedures are not representative of the real action of reinforced concrete beams under working loads. Neither are they representative of ultimate load conditions. They are totally artificial and have been applied with allowable unit stresses empirically adjusted to give safe results."

It is then suggested that ultimate strengths are not only easier to determine but also more realistic. The failure patterns are next developed, at first definitely excluding the progressive cracking on the tension side and considering this area as though initially cracked.

A tension failure is associated with a rising neutral axis as the steel passes its yield point. The rising axis reduces the compression area until a secondary compression failure follows. Deflection is greatly increased near failure. No mathematical analysis of any of this is attempted at this stage.

A compression failure develops with a lowering of the neutral axis and a significant increase in the area under compression. Failure is sudden, without much prior warning.

A balanced beam (at failure) is defined, and the small effect of greater tension steel than this amount is noted. The small effect of shrinkage and creep upon ultimate strength is also pointed out.

At this point the student has a good picture in mind of concrete beam action and is ready for algebraic treatment. Whitney's ultimate strength relations are then presented very simply:

1. The stress block as a substitute conception for C.
2. $M_{ult} = (1/3) f'_c b d^2$ as an impirical relationship for a compression failure.
3. Tension failure measured by the secondary compressive failure, for which the final stress block is just deep enough to give $C = A_s f_y$.
4. The maximum stress block, empirically determined by Whitney as 0.537 d in depth, which defines a

balanced section. Further steel adds little (nothing at all according to Whitney).

A few very brief problems are assigned to illustrate Whitney's method.

A parabolic stress distribution problem for a compression failure is given next, as an example of related procedures in use 50 years ago. No attempt is made at this stage to discuss double-reinforced beams, T-beams, or combined direct stress and bending. The load factor, to get desired ultimate moment from working loads, is briefly mentioned. A total of four or five periods is required for all this beam treatment.

Working Stress Methods Related to Tests

The course then reverts to standard working stress methods. The ultimate strength theory is, however, often used for comparison or reference. For instance, the allowable moment by the allowable stress theory (on an overreinforced beam) is compared to the Whitney ultimate moment value. This gives the opportunity for a definition of factor of safety in terms of load factor instead of the ratio of ultimate stress to working stress.

When beam compression steel is introduced in the course, the effect of shrinkage and concrete creep (or flow) on columns is briefly reviewed, noting that high steel stresses, much in excess of nf_c, were revealed by these tests. This discussion makes a compression steel stress limitation of $2nf_c$ seem rather reasonable.

The present treatment of combined direct stress and bending presents a philosophical problem. The calculation of "stresses" here when we know we cannot do this even for the simple axial load is awkward, to say the least. This material is presented as the necessary patch-work between an ultimate strength theory for columns and a working stress theory for beams. Fortunately there appears to be a good chance that the next A.C.I. Code, in 1955, will improve this situation by adopting a relation similar to the one used now in steel design: $f_a/F_a + f_b/F_b = 1$.

Other areas also need to be introduced from an experimental viewpoint. The subject of footings can be initiated with a brief review of Richart's 1948 tests. Although diagonal tension design has had very little recent data to support it, extensive tests at the University of Illinois will shortly be reported that will call for a complete realignment of ideas in this area. Recent tests at the University of Texas indicate that some new factors must be considered in the field of bond stress. Although not all of these factors are included in the usual concept of ultimate strength theory, they all measure ultimate strength in some form and seem properly a part of the overall theory.

Summary: The Elementary Strength of Materials Approach Is Inadequate

The main thesis of this paper is derived from the considered opinion that reinforced concrete design theory should not be treated as a simple adaptation of the junior strength of materials course. Where it has been so treated, unrealistic relationships have resulted that ultimately have to be discarded or modified. Reinforced concrete is in fact so complex in action that its behavior can be predicted with satisfactory accuracy only on the basis of laboratory investigations. Investigation at times leads to results agreeing with elementary theory; but just as frequently it does not.

It follows that our emphasis in senior courses should be on this empirical or experimental approach. When we neglect this approach our students go out with a false sense of security. They are not prepared to accept promptly the inevitable changes in concrete design that lie ahead. The slow acceptance of ultimate design theory to date and the antagonistic reaction it first receives from many engi-

neers are evidence that the engineering schools have *not* done a good job in preparing students for change.

Present concrete theory is certainly not infallible. It certainly ought not to be taught as though it were. Unfortunately, textbooks are not yet ready to lead the profession in this fashion. The teacher must work out his own supplementary material. Nevertheless, the basic reinforced concrete course can be a most satisfying effort to any teacher who really accepts this challenge for a realistic empirical approach.

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

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The Professional Union—A Contradiction*

By CLARENCE T. SHOCH

Vice President, Northeastern Region, National Society of Professional Engineers

Let us permit our imaginations to run freely just a moment and picture ourselves sitting in at a convention held in Los Angeles in February, 1953, with men who call themselves engineers, and hearing the speaker utter the following words:

> We must . . . expose those employer-dominated groups who purport to speak for engineers and scientists, but who in reality speak for management. These groups, such as NSPE, are controlled entirely by management people who are so far removed from the engineering employee that they cannot possibly know his problems, his desires or his needs.
>
> . . . collective bargaining . . . is by far the most direct and the most potent device . . . we have to assist us in obtaining our goal.
>
> Economic weapons such as strikes shall be resorted to . . . when . . . other avenues toward settlement of the differences have been . . . explored and found unworkable.
>
> We must establish closer relationships with the science and engineering students in our colleges and universities.
>
> We must make our various publications available to them;
>
> We must encourage our members and leaders to write articles for their department or college organs.
>
> We must inform . . . students that
>
> (a) Employers are hoarding engineers and scientists
>
> (b) The engineering shortage is largely synthetic
>
> (c) Glamorizing engineering as a profession to attract more students to engineering courses should be stopped.

Those words were spoken by one whose organization has the stated objective, incongruous though it may be in part—"To promote the economic, *professional* (emphasis added) and social welfare of engineering and scientific employees." The speaker was, of course, the President of the Engineers and Scientists of America, on the occasion of the first convention of that group. The philosophy expressed is that of collective bargaining. The words have a sinister sound to us, and portend a situation in engineering circles totally foreign to the generally accepted philosophy of a professional man.

It must be definitely understood that what we are about to discuss is not to be an indictment of unions. Neither will it be a blanket endorsement of management. The pattern of economic relationships existing in our system of devising and producing this world's goods is far too complex to permit any broad conclusion that the labor practices of either unions or managements have been either (a) the salvation of this country's economic leadership, or (b) its greatest obstacle.

Our immediate problem really has little to do with employers or employees as such, although we will unavoidably explore areas where better understanding between those groups would facilitate a decision we must make for ourselves as members of the engineering profession—that of whether to hold to the principles of professionalism or accept the collective bargaining concept. We can't do both. Somewhere along the line we must take a stand in support of our consciences.

* Presented at the Allegheny Section Meeting of ASEE, April 30, 1954.

ESA as a Symbol

Taken more or less as a symbol of the problem we face, let us review the progress that has been made in the aforementioned new organization of engineers—that of the Engineers and Scientists of America, a nation-wide federation of bargaining units. The units comprising this federation are, otherwise, "independent" unions, established in plants and at locations as follows:

The net representation of this group is approximately 21,000. ESA claims to have applications from other groups with representation totalling 15,000. The grand total accounts, roughly, for their claim of 40,000 representation. Remember though, the actual membership in these unions may be substantially less, for under the law a union needs only a simple majority of those eligible to vote for representation to be in a position to claim representation for the entire group.

Union Name (1)	*Company* (1)	*Claimed* (2) *Representation*
Assn. of Engrs. and Engin. Assistants	G. E. Switchgear Works, Phila., Pa.	240 (3)
	Shell Development, Emeryville, Cal.	400
Assn. of Industrial Scientists	R.C.A., Camden, N. J.	810
Assn. of Professional Engin. Personnel	W.E. Co. (Nation-wide)	5,000
Council of Western Electric Tech. Employees		
Engineers and Architects Assn.	Lockheed Aircraft, L. A.; Lockheed-Aircraft Service; Consolidated-Vultee Aircraft, San Diego; Rheem Manufacturing, L. A.; City and County of Los Angeles	4,800 (4)
Engineers Association	Sperry Gyroscope, Great Neck, N. Y.	1,900
Engineers Association of ARMA	Arma Corp., Garden City, N. Y.	740
Engineers Guild of Oregon	Timber Structures, Portland; Engineers of the State of Oregon	300
Minneapolis Federation of Honeywell Engrs.	Minneapolis Honeywell Regulator, Minneapolis, Minn.	1,040
San Francisco Area Group of Prof. Engrs.	Pacific Gas & Electric Western Assn. of Engrs., Architects and Surveyors, City of Alameda; East Bay Municipal Utility District	450
Seattle Prof. Engin. Employees Assn.	Boeing Airplane, Seattle, Wash.; Continental Can, Seattle, Wash.	3,500
Southern Calif. Prof. Engin. Assn.	Douglas Aircraft, San Diego; Southern Calif. Gas, L. A.	3,000 (3)
TVA Engineers Assn.	Engrs. of the Tennessee Valley Authority, Southeastern U. S.	2,000
(5) Federation of Arsenal Engineers	Twin City Arsenal Plant of Federal Cartridge Corp., St. Paul	125
	Total	24,305
	Less recent withdrawals	3,900
	Net	20,405

(1) According to recent Congressional testimony.
(2) According to CWETE "Council Compass" for January, 1953.
(3) Recent information indicates that these unions are not current members of ESA.
(4) Recent information indicates that decertification of the Lockheed, Marietta, Ga., unit (1/15/54) has reduced this number approximately 660.
(5) This unit not in original testimony, and is according to the November–December, 1953, issue of *ESA News Digest*.

The Problem Is Not Just Another Engineering Group

Our concern is not that another engineering-type organization has come into being, even one of claimed representation of some 40,000 engineers. We are apprehensive, however, of the stated aims and objectives of this organization, which are at extreme variance with the more altruistic motives expressed by the long established professional engineering societies and associations.

Further, we are concerned with their expressed intent of going into engineering schools and promoting their doctrines to the embryo engineers who will wind up on the management side of the bargaining table in a great majority of cases. To have these young people indoctrinated with purely mercenary motives cannot help but seriously retard, and possibly permanently injure, their chances to achieve maximum success and satisfaction in their chosen careers.

How has the engineering profession been maneuvered into this peculiarly contradictory situation of professing on the one hand to devote its combined talents to the benefit of mankind, and on the other, to foster activities which are extremely controversial as to their public interest value?

Representative Carroll D. Kearns, speaking before the House Committee on Education and Labor in May, 1953, remarked that "With the passage of the Wagner Act in 1935 it became the policy of the United States Government to foster and promote the concept of collective bargaining as the most satisfactory method of resolving differences and disputes between labor and management." Let's review some of this labor legislation history, particularly as it applies to engineers and their inclusion in the labor category.

Engineers as "Labor"

Representative Kearns' reference to the passage of the Wagner Act in 1935 takes us back to a period when engineers, and practically everyone else in the country, were living through an era of "made work." Under the Government's philosophy of fostering labor's interests, employed engineers were considered to be the same kind of commodity as any other trade or type of employment, and as such were similarly subject to the provisions of the Wagner Act.

But the engineers were "babes in the woods" at the game of organizing for labor advantage. Their numbers among the labor masses, of which they were by law a part, were so insignificant as to make it practically impossible for them to express their wishes, let alone hope that their desires might be given consideration. Most of the time, the objectives and philosophy of the great numbers of the laboring classes were completely out of tune with the philosophy that had been developed by these engineers as a result of their college training and their association with older engineers having the true professional concept.

Despite a lack of common interest between professional engineers and the crafts in the same labor union, it was almost impossible for the professional employees to withdraw. They had to retain membership to hold their jobs and, in many instances, were forced to take part in strikes under the thinly veiled threats commonly used by unprincipled labor groups. No provision in the law would permit engineers and similar professional-type personnel to be classed as professionals, or apart from the usual crafts.

Introduction of the "Professional Provisions" of Taft-Hartley

Events led to a change, however, and in 1946 it became apparent that the Wagner Act would give way to more enlightened over-all considerations.

At that time a determined drive was made by a combined grouping of professional engineer societies consisting of the National Society of Professional En-

gineers, the Engineers Joint Council and the American Society for Engineering Education. This group appeared before committees of Congress and eventually introduced into the new labor law of the land, the so-called "Professional Employee" Provisions. This law, still the ruling document in labor matters, is known as the "Labor Management Relations Act, 1947," or more commonly as the "Taft-Hartley" law.

The so-called professional provisions of Taft-Hartley have been supported vigorously during all meetings of the Congress since 1947. Our group and the professional engineer allies previously mentioned, rallied in 1949 in vigorous support of retaining the professional provisions. These provisions were subjected at that time to the determined efforts of the heterogeneous type unions which, of course, did not want that potential membership to slip away from them.

Again in 1951 there was concerted Taft-Hartley activity by the professional groups. This past Spring, both the National Society and the Engineers Joint Council appeared before committees of both houses of Congress in support of the professional provisions. At that time, the National Society also proposed a further amendment, popularly known as the "Freedom of Association" Bill, H.R. 5504, introduced by Representative Kearns. As you know, the whole subject of Taft-Hartley is presently a matter of national controversy and nothing has been done recently about revising that law.

At this point it would be helpful to review the actual passages in Taft-Hartley which bear upon the development of professional unions among engineers. In an attempt to avoid confusion, some of these passages have been briefed to omit words or phrases not particularly pertinent.

What Is a Collective Bargaining Unit?

Sec. 9 (b)—"The Board shall decide . . . the unit appropriate for the purposes of collective bargaining. . . . Provided, that the Board shall not . . . decide that any unit is appropriate for such purposes if such unit includes both *professional employees* and employees who are not *professional employees* unless a majority of such *professional employees* vote for inclusion in such unit; . . ." (emphasis added).

Note that the foregoing mentioned "professional employees."

Who Is a Professional Employee?

Sec. 2 (12)—"The term 'professional employee' means—

(a) Any employee engaged in work
  (i) Predominantly intellectual and varied in character as opposed to routine mental, manual, mechanical or physical work;
  (ii) Involving the consistent exercise of discretion and judgment in its performance;
  (iii) Of such a character that the output produced or the result accomplished cannot be standardized in relation to a given period of time;
  (iv) Requiring knowledge of an advanced type in a field of science or learning customarily acquired by a prolonged course of specialized intellectual instruction and study in an institution of higher learning or a hospital, as distinguished from a general academic education or from an apprenticeship or from training in the performance of routine mental, manual, or physical processes; or

(b) Any employee, who
  (i) Has completed the courses of specialized intellectual instruction and study described in clause (iv) of paragraph (a), and

(ii) Is performing related work under the supervision of a professional person to qualify himself to become a professional employee as defined in paragraph (a).

These are the parts of the law commonly spoken of as the professional provisions of Taft-Hartley.

Supervisors Are "Out"

At this point it would be well to remember that "supervisors" are specifically barred from participating in collective bargaining. The provision of the law governing this states:

Sec. 14 (a)—". . . no employer . . . shall . . . deem . . . supervisors as employees for . . . collective bargaining."

This provision has a bearing on some of our later considerations.

Freedom of Association Amendment

Following are important quotations from the law in that they establish the basis for NSPE's proposed Freedom of Association amendment. The first pertains to a definition of a labor organization.

What Is a Labor Organization?

Sec. 2 (5)—"The term 'labor organization' means any organization of any kind, or any agency or employee representation committee or plan, in which employees participate and which exists for the purpose, in whole or in part, of dealing with employers concerning grievances, labor disputes, wages, rates of pay, hours of employment, or *conditions of work*" (emphasis added).

In the above it is very important that we keep in mind the words "conditions of work." These words used commonly in terms of employment might be expected to mean simply the adequacy of shop or office equipment, proper toilet and wash room facilities, elevator service where necessary, clean, well-ventilated working spaces, lunch and locker rooms, etc. However when dealing with a law which has been established primarily *for the aggressive protection of the working man,* it is entirely possible that the words "conditions of work" would also be interpreted to include the activities of groups of employees growing out of their efforts to devote themselves to professional development and professional recognition, and where working conditions were only collateral considerations. This might come about, for example, if the plan for the professional development of engineers in a plant included the scheduling of their employment in various jobs on a rotation basis, or encouraged them to use their own free time in the laboratory or shop in the interest of self-development.

In some instances, professional engineers have formed local associations within a plant which are not, and are not intended to be, collective bargaining agencies, but rather are designed to provide a vehicle whereby all professional engineer members may consider their mutual problems. These local associations or groups, sometimes referred to as "sounding-board" groups, include within their membership both employee professional engineers and management professional engineers, the reasoning being that all such personnel are members of the same profession, and consequently have mutual professional interests. This is desirable because without such integration at all levels of professional thinking, the profession loses its cohesive nature and the benefit of open interchange of ideas, opinions and comments. A "problem" exists because the management professional engineers are included in the membership of these local associations or groups, for both the group itself and the employing company might be cited for an unfair labor practice under the following provision of the law.

What Is an Unfair Labor Practice?

Sec. 8 (a)—"It shall be an unfair labor practice for an employer—

(1) To interfere with, restrain, or coerce employees in the exercise of rights guaranteed . . . .

(2) To dominate or interfere with the formation or administration of any labor organization or contribute financial or other support to it: . . ."

Because of the integrated nature of local engineer groups and because in their operations they may touch upon working conditions, they are under a constant cloud of being attacked as company-dominated labor organizations in view of the broad legal definition of the term "labor organization." Company domination is considered possible because the management professional engineers in the group might be construed as using their influence and membership participation to sway the general membership away from collective bargaining.

The following quotation from the Seventeenth Annual Report of the National Labor Relations Board bears on this situation:

> The Board customarily finds a labor organization to be employer-dominated where its formation was instigated or encouraged by the employer, where supervisors or other management representatives participated in its formation or have a voice in the administration of its affairs, and where the employer provides financial or other support in the organization.

Permit Professional Men to Make Own Choice

We are of the opinion that professional personnel are intelligent enough to elect between collective bargaining and any other channel of communication with management, and are not likely to be dominated in that choice. Nor do we feel that the public interest is served by a condition of the law which tends to encourage one choice while placing limitations upon the other.

The full and free interchange between all members of the engineering profession has been a vital factor in the industrial development of the nation. In fact, it is the way in which the profession has progressed in its technical advancement for more than a hundred years. The technical organizations of the profession make no artificial distinctions in meetings and publications as between those who are employees and those who are management. The same lack of distinction in matters of professional development and activity is needed for continued industrial progress.

NSPE's Proposed Amendment re: Freedom of Association

Those professional employees who desire to be represented through a union and collective bargaining procedure should be permitted to do so. Those who do not should likewise be protected in their rights. Such a result may be achieved by the simple step of having the law specifically permit the members of a profession, including both employee and management personnel, to form and participate in organizations to consider mutual professional problems if those persons have not affiliated with, or are not represented by, a union. This can be accomplished by having that part of the law defining a labor organization amend as follows (proposed amendment in italics):

> Sec. 2 (5)—"The term 'labor organization' means any organization of any kind, or any agency or employee representation committee or plan, in which employees participate and which exists for the purpose, in whole or in part, of dealing with employers concerning grievances, labor disputes, wages, rates of pay, hours of employment, or conditions of work. *Provided, that the term 'labor organization' shall not include organizations of professional per-*

sonnel as defined in Section 2 (12) of this Act if the Board has not certified or the employer has not recognized a representative as their representative under Section 9."

The above proposed revision of Section 2 (5) is the proposal of Representative Kearns in House Bill 5504, known to us as the "Freedom of Association" Amendment.

Now back to ESA for a moment. ESA has proposed in their testimony before the House Committee that the Taft-Hartley law be revised in several respects. Here are their particular points, amplified by the apparent reason for their suggestions.

ESA's Suggested Taft-Hartley Changes

1. A redefinition of supervisory employees to exclude those not having "true management functions," to make a greater number of professional personnel available for union membership.

2. A prohibition to cause employers to cease dealing with other than legitimate unions on the subject of wages, hours and working conditions. This would outlaw the sounding-board type of engineer groups described previously.

3. Application of Taft-Hartley to employees of public agencies and wholly owned government corporations. This would permit engineer employees of TVA, etc., to carry on all collective bargaining tactics, including strikes.

4. Repeal of the Free Speech Provisions in Taft-Hartley, thereby curbing an employer's right to speak to his employees concerning their organization for bargaining purposes.

5. Repeal of the Decertification Provision. This would eliminate the possibility of engineer employees getting out from under union organization.

6. Elimination of the imposition of respective state laws on union security and check-off, which now prevent these matters on a state-by-state basis.

7. Freedom to bargain without restraint or limitations. They want no restriction placed upon nation-wide or industry-wide collective bargaining.

How Others Contrast the Professional-Union Philosophies

As an interesting sidelight on the proceedings before the House Committee, I offer the following quotation from the transcript of the record to indicate the attitude of one of our eminent legislators on the comparison of the professional philosophy vs. the collective bargaining concept. This bit of repartee took place toward the close of the questioning by the Representatives who had heard NSPE's and EJC's testimony advancing the professional philosophy, followed by the testimony of ESA which had suggested many changes in Taft-Hartley strictly along the lines of the union approach. Chairman McConnell stated to ESA President Amann:

"I must confess that I had not seen the opening part of your statement where you say you are a federation of labor unions. Now I can begin to understand. I was thinking of you as an engineering society. I thought you were taking on all the characteristics of a labor union. I couldn't understand it."

After Mr. Amann had confirmed that the ESA groups were certified collective bargaining labor unions, Chairman McConnell continued:

"These gentlemen," pointing to the NSPE and EJC representatives, "to make sure, are what I understand is an engineering society. I can get the difference in your philosophy and background now when I get that additional understanding. I didn't have it before. I thought this group (ESA) were talking like a labor organization and this group (NSPE and EJC representatives) like a professional society. I thought you were all professional societies and it was confusing to me."

Mr. Amann—"I should like to suggest, Mr. Chairman, that we are as professional as this group, if I may."

Chairman McConnell—"You may be in your background, but in what you advocate here you are taking on very definitely to me, as we understand the jargon, the labor organization viewpoint."

Mr. Amann—"That is right. We are a labor organization."

Professional-type Organizations

So much for the union concept. Getting along to the comparison between the philosophies of a truly professional man and the union concept, let us consider some of the stated objectives of groups which are known for their professional-type activity. There are a number of organizations which accept the professional concept of engineering and have established their objectives and principles accordingly. Four which operate on a national scale and across all of the branches of the profession are:

Engineers Council for Professional Development
American Society for Engineering Education
Engineers Joint Council
National Society of Professional Engineers

In addition, certain local associations exist entirely within specific industrial companies employing large numbers of engineers. These are the so-called sounding-board groups:

Consolidated Edison Forum
Bell Telephone Laboratories Conference
Humble Oil Society
General Electric Engineers Associations

Comparison of NSPE–ESA Objectives

The objectives of these professional societies and associations are stated, in part, in words and phrases that have been parroted by ESA. For example, the National Society of Professional Engineers was organized with the objectives of—

> The advancement of the public welfare and the promotion of the professional, social and economic interests of the professional engineer.

ESA changed this only slightly, advancing the economic considerations ahead of the professional and social, leaving out any concern for the public.

One other important professional group, the Engineers Council for Professional Development, has this objective—

> To coordinate and promote efforts to higher professional standards of education practice, greater solidarity of the engineering profession and greater effectiveness in dealing with technical, economic and social problems.

Professional Society Objectives Require Close Coordination of Experiences at All Levels of Development

While the ESA statement of objectives and those of the professional societies may read somewhat alike, ESA's concepts of the individual engineer's position in economic and social matters differ materially. Their visualizations of the goal and descriptions of the road are different. So now the picture of the basic problem is coming into focus.

The final goal of the individual engineer starting to climb the ladder to professionalism may appear to be the same whether he takes the road to unionism or to true professionalism. Actually these roads lead to entirely different terminals of material and mental value, coloring the objective along the way. And so, a dividing point in the choice of groups is at hand. Shall the young engineer be guided from non-supervisory to supervisory level by labor union leadership, or shall he be encouraged and helped upward through his pre-professional training period by the older, more experienced engineers who have reached full professional stature?

The ability to make an intelligent choice between two such alternatives re-

quires that engineers, both young and older, have a sound knowledge of the characteristics and advantages of a profession, as contrasted to those of a union. Let us review some of the concepts of a professional man.

The Professional Philosophy

First, what is a profession? A profession has: basic characteristics, group attributes, principles of social duty, individual associations and recognized obligations.

The *basic characteristics*—

An attitude of mind—an altruistic motive can lift an honorable calling to the professional level.

A kind of work—special skill on a high intellectual plane.

An order in society—the bar, bench or clergy.

A confidential relationship—the doctor and his patient, or the lawyer and his client.

The *group attributes*—

A body of knowledge, held as a common possession and extended by united effort.

An educational process, to be guarded diligently.

A monopoly granted by the public, on a self-governing basis.

The *principles of social duty*—

Guarding the ideals and standards of the profession.

Advancing the profession in public understanding and esteem.

Sharing advances in technical knowledge.

Rendering free public service.

Bringing group knowledge to public and civic problems.

Establishing a substantial voice in public policies.

The *individual associations*—

A type of activity, motivated by a feeling of high individual responsibility and requiring special skill applied on a distinctly intellectual plane.

A motive of service, based upon limited rewards apart from profit.

A standard of personal qualifications, requiring character, training and proved competence.

A standard of conduct, recognizing courtesy, honor and ethics.

A motive of self-expression, joy and pride in the work and a self-imposed standard of excellence.

The *recognized obligations*—

Service above gain.

Excellence above mediocrity.

Pride above monetary reward.

Loyalty above individual advantage.

Dr. Steinman's Summation

These points were well summarized and related to the collective bargaining concept by Dr. David B. Steinman, first President of NSPE, when he said:

The usual methods of unions (coercion, strikes, picketing, closed shop, etc.) should be unthinkable in a profession. Such methods are inconsistent with all of the ethical ideals of a profession.

Engineers occupy a position of confidence and trust between capital and labor, and between employers and employees. Unionization is inconsistent with the highest discharge of that trust.

Unionization places the sole emphasis on wages and hours, and on union membership, instead of emphasizing qualifications and quality of service.

Unionization tends to pull all members of a profession down to the same level, discouraging individual effort, loyalty and ambition.

Unionization is identified with the trades. Unionization of engineers undoes the work of years in winning public recognition of engineering as a profession.

Unionization is inconsistent with the professional spirit and attitude, which places service before profit, the honor and standing of the profession before personal advantage, and the public welfare above all other considerations.

Harmful Effects of the Collective Bargaining Concept

Summarizing the harm engineering unions can do us as individuals and as a profession:

First, for engineers as individuals:

There would be a classification of engineering positions, with minimum standards.

Initiative would be discouraged, individual recognition stifled, opportunities limited, and advancement retarded.

Personal prestige would be damaged and professional recognition diminished.

A "leveling" of salaries would result, and regimentation would follow.

Second, for the engineering profession as a whole:

The desire for higher intellectual attainments would be sacrificed to the concern for immediate advantages.

The confidential relationships inherent in professional service would be lost in the hypocrisy of lip service.

Stratification, fragmentation and splintering of the profession would continue.

Proper Education Needed to Stem the Collective Bargaining Trend

A more important question which must be answered, however, is: "Where do we go from here?" To be truly helpful in this situation, we must be able to recommend to the engineering profession a course of action designed to counteract effectively the challenge of unionism. With long-range vision of the problem, NSPE took its first major step by adopting a Statement of Principles in June, 1950, reaffirmed in November, 1952, which reads as follows:

It is definitely unprofessional for a professional engineer, professionally employed, VOLUNTARILY to join a heterogeneous labor union, dominated by, or obligated to, nonprofessional groups. As stated by the Society, through its Board of Directors at Oklahoma City in September, 1948, "The individual responsibility and independent judgment required of a professional engineer are incompatible with the regimentation fundamentally inherent in unionization."

In further answer to the question, I suggest vigorous support of a three-level program of education directed toward *engineering employees, engineering management,* and *engineering students.* Let us consider how each of these groups can participate and contribute its proportionate share toward a satisfactory solution of the problem.

Engineering Employees' Development

First, *engineering employees,* as individuals, must continue to develop professional vision according to the concepts outlined above in the discussion on what constituted a profession. A public statement emphasizing this was made only recently by Mr. T. Carr Forrest, Jr., President of NSPE, who expressed the following viewpoint:

In a large eastern newspaper of recent date there appeared the headline, "RCA Engineers Announce Strike." In the same newspaper, the next day, "RCA Engineers Call Off Strike." Here was a case where a union of professional people (and the word 'professional' is in the title of the union name) calling upon their weapon of last resort to force their point of view. Regardless of the particular issues in that situation, can professional people go before the public one day in terms of strikes and picket lines, such as are used by production workers, and go before the public another day, as we do during Engineers' Week and upon other occasions, talking of public service and asking the public to bestow their blessing and recognition on us as a professional body entitled to that public distinction because of our endeavors to obtain advanced knowledge for the public good as well as our own good?

One of the obvious hallmarks of professionalism is individualism and the right

to make one's own way in improvement in the economic ladder, and certainly, at least in the professional ladder. This agreement (between RCA Engineers and Management) may be to the economic advantage of the engineers for whom it was negotiated, but I maintain that when an individual professional engineer is 'represented' by force of law and collective bargaining agreement to the extent of almost every phase, detail and aspect of his daily professional activities, it cannot be successfully maintained that collective bargaining is compatible with his status as a professional man. If your professional development and advancement are to be regulated in 35 ways as part of your daily activities, you may or may not climb the professional ladder, but you will climb it, if at all, only on the rungs which are contained in the 'agreement' and you will climb it no faster than the 'agreement' permits.

Engineering Managements' Development

Second, *engineering managements* must be informed to the point of obtaining a full understanding of the problem and an appreciation of the consequences inherent in the alternatives. Specific thoughts in this vein were expressed by the late Dr. Karl B. McEachron of the General Electric Company, in a letter dated October 5, 1953:

As I see it, it is highly important that management take time off to find out what their engineers can do for them in terms of satisfying accomplishments. While there will be some cases where the engineer can be completely a lone worker, in the majority of cases he is going to require a certain amount of assistance of various kinds or else we are going to waste his talents and training. Obviously many engineers do not get in this position in the first year or two but certainly for most of them inside of the first four or five years they ought to be in a position where they have grown enough so that their contribution should be a significant one, and if conditions are right, a continuing one. Personally, I think the employer is the key to this whole situation, and when I say 'employer' I mean not only the employer in industry but I mean the administration of our colleges, professors, and others, and the client who employs an engineer or a consulting firm to do work for him; also, of course, the municipal, state and governmental agencies as well.

Managements Are Making Good Progress

It is truly encouraging to know that the managements of some corporations employing large numbers of engineers, scientists and technicians, have recognized the problem and are carrying out detailed and specific programs of mutual education. The purposes and characters of these programs are many, but they all are directed toward the establishment of mutual understanding and cooperation between management and the engineer as a professional employee. Some of the more important of these industrial programs are:

- Adequate orientation, including a complete explanation of company policies and procedures.
- Opportunity for personal development through further education, adequate training, professional registration, effective speaking and the preparation of technical articles and special reports.
- Enlightened salary administration through frequent appraisal and rating of the individuals.
- Recognition of educational attainments and technical proficiency.
- Utilization of professional personnel in appropriate capacities and for work of engineering character. Provision of adequate opportunity for advancement.
- Sponsoring membership in professional and technical societies. Sponsoring registration, and assisting in the development of refresher courses. Encouraging participation in community affairs.

While the task of management appears monumental, actually it can be overdone, as pointed out by Mr. Clark Ransom of General Electric Company, who addressed the annual meeting of NSPE

at Daytona Beach, Florida, in June, 1953, on the subject of "The Professional Development of Engineers and Scientists in Industry." Mr. Ransom spoke as follows:

Some of you may be raising the question, 'Why does not the employer assume responsibility for the professional development of the engineering and scientific personnel?' Management *is* contributing to the broader career development of these people. I am sure that there is more that management can and will do. But there are areas in the field of professional development which are not the responsibility of the employer. A paternalistic employer who 'holds the hands' of the engineer and does his thinking for him is encouraging dependency and incompetency. Such practices can be just as damaging as the regimentation imposed by collective bargaining.

Engineering Students' Development

As the third and equally important phase of this program, the *engineering students* must be exposed to the need for making an ultimate choice between unionism and professionalism. Here is the way an outstanding educator, Dean W. R. Woolrich of the University of Texas and Past President of the American Society for Engineering Education, sees the situation:

The answer to either the students of the engineering colleges or to the man who plans to grow is not unionism. The reward for which the professional engineer strives is a composite of full recognition and appreciation for the manpower product of the engineering colleges by those who employ, advise and direct.

The future of engineering as a profession in North America depends upon the ability of the engineering colleges to advance their education to new levels of professional achievement. The *incentive* for both students of engineering and the engineering colleges, however, is in the hands of those who direct the progress of the graduates after they leave the college halls.

The future is not too bright in collective bargaining for advancement of men of creative genius and individual professional abilities. Collective bargaining is never inspirational to the man of creative talents, and recognition cannot be readily afforded him other than as a part of a collective group.

The Engineers Joint Council, The Engineers' Council for Professional Development and the National Society of Professional Engineers now face the alternative of speeding up their coordinated effort to improve the professional status of the recognized engineer or giving way to a less discriminating group of union engineers who would like to speak for all of us on the workman's side of the collective bargaining conference table.

NSPE Is Already Active in Supporting the Professional Attitude

You should know that *your* professional society is contributing much toward the solution of this problem by education at the three levels specified. NSPE has a broad program directed toward engineering employees, managements and students, which is well under way in many of its phases. The details of these programs are too numerous to present here, but your attention is directed toward the current work and official reports of committees, as follows —with Chairman and State location to indicate country-wide consideration:

Employment Practices—Mr. Alfred J. Ryan, Chairman (Colorado)

Education—Dean W. R. Woolrich, Chairman (Texas)

Young Engineers—Prof. E. W. Carleton, Chairman (Missouri)

Public Relations (including National Engineers' Week)—Mr. E. W. Seeger, Chairman (Wisconsin)

Professional Engineers Conference Board for Industry—Mr. John D. Coleman, Chairman (Ohio)

These executive research survey reports already issued:

(1) How to Improve The Engineering-Management Communications

(2) How To Improve The Utilization of Engineering Manpower
(3) How To Attract and Hold Engineering Talent

Special Industry Committee—Mr. R. A. Blackburn, Chairman (Pennsylvania)

The Head-on Collision of Philosophies

The history of engineering is one of grand achievement. Public recognition of the value of the profession has been based upon the intimate knowledge and experience of the man in the street, of the ways in which the engineers' plans, developments and products have made life more pleasant and more profitable. Much of the public's appreciation has stemmed from the certainty that mechanization and production line methods have, time and again, multiplied the numbers of jobs available.

Thus, the engineering profession has earned its present degree of public esteem on the basis that it "makes work"—useful work. In the face of this proved formula for enhancing our professional reputation, those who would have engineers bargain collectively as a means of economic gain have advocated work stoppages as the means for attaining their ends. It is my conviction that the profession would lose immeasurably, and you and I would suffer significantly, were we to change in the slightest our tried and true approach to the further enhancement of the profession, and to your and my self-satisfaction.

The Contradiction Is Clear

As a conclusion to this presentation of the contrasting philosophies of collective bargaining groups and professional engineering organizations, let us emphasize our confidence in professionalism as a way of life in engineering by quoting the well-known and thought-provoking words of the late Dr. William E. Wickenden, who wrote:

> Every calling has its mile of compulsion, its daily round of tasks and duties, its standard of honest craftmanship, its code of man-to-man relations, which one must cover if he is to survive.

I break in at this point to concede willingly that the union concept is not in violent disagreement with Dr. Wickenden's remarks thus far, which pertain to man's selfish motives. However, the professional concept, and the great contradiction to the collective bargaining philosophy, is emphasized by these words:

> Beyond that lies the mile of voluntary effort, where men strive for excellence, give unrequited service to the common good, and seek to invest their work with a wide and enduring significance.
>
> It is *only* in this second mile that a calling may attain to the dignity and distinction of a profession.

The parting of the way is immediately ahead—down the road to unionism, up to professionalism. The upper road, figuratively and literally, is a harder route, but amply rewarding in the vastly improved outlook for a lifetime devoted to the advancement of the engineering profession.

Let's Take Another Look at the Causes for Professional Bargaining Groups

By A. A. K. BOOTH

Director, ASCE

The Taft-Hartley Act provides a statutory definition of a professional employee and establishes principles under which such individuals may form a unit for collective bargaining purposes, or may join any other unit for the same purposes, or may even refrain from participating in collective bargaining. The Board that administers the Act is under no obligation to police the contracts so it is the responsibility of professionals to be aware of their prerogatives under the Act to ensure to themselves the prerogatives granted by the Act. The Act does not vindicate the action of a professional group. It merely affirms their legal rights.

The Act states in Section 9(b) that:

> The Board shall decide in each case whether, in order to assure to employees the fullest freedom in exercising the rights guaranteed by this Act, the unit appropriate shall be the employer unit, craft unit, plant unit or subdivision thereof: PROVIDED that the Board *shall not* (1) *decide* that *any unit is appropriate* for such purposes if such unit *includes both professional employees and employees who are not professional employees unless* a majority of such *professional employees vote for inclusion in such unit.*

By statutory definition a "professional employee" is an individual who has "knowledge of an advanced type in a field of science or learning customarily acquired by a *prolonged course* of *specialized intellectual instruction and study in an institution of higher learning* or a hospital as distinguished from a general academic education or from an apprenticeship or from training in the performance of routine mental, manual or physical processes." It is clear that the professional employee is no ordinary person: it is equally clear that he must have, except in exceptional cases, a substantial professional education in an institution of higher learning.

Engineering educators must then view with concern any move by professionals to join by their own volition with nonprofessionals in units for collective bargaining purposes. Something must be wrong when this occurs.

T. H. Evans, Dean of Engineering, Colorado A and M. College, suggests in his paper "Let's Look at the Causes for Professional Bargaining Groups" (1) a possible difficulty. Dissatisfaction with a Plan, Plan "A"—one of the four of the so-called Plans A, B, C and D, prepared by task committees of the Exploratory Group representing fifteen National Engineering Societies interested in a Unity Organization for Engineers. He suggests that dissatisfaction with the Unity Organization developed under Plan "A" caused professionals to seek elsewhere for a suitable home. He suggests that they found an acceptable home in the Engineers and Scientists of America which, to use his words, is "merely a national federation of member units set up to handle employer-employee relations." Let us take a quick look at two of the organizations that have affiliated with the E.S.A.

The Engineers Association at Sperry, composed, to quote Joseph Amann, President, E.S.A., of "professionals" affiliated with E.S.A. The Association was on strike quite recently. It placed an advertisement in the *New York Times* of March 11, 1954, demanding among other things, "a contract incorporating legitimate gains that have been granted to *all other unions*, such as union security and job security. The Engineers' Association of Arma, Brooklyn, N. Y., is also affiliated with the E.S.A. It conducted a strike last summer. It *honored* the *picket lines* of the C.I.O. International Union of Electrical, Radio and Machine Workers.

Non-Professional Tactics

Both Associations adapted tactics that resemble closely those followed by non-professionals. Their actions raise two questions. First, would the task committees representing the fifteen national engineering societies have designed a Unity Organization that could tolerate non-professional conduct? Second, did any of the plans—A, B, C or D—envision a Unity Organization with which the Engineers' Association at Sperry or the Engineers' Association of Arma would care to affiliate?

There seems little doubt but that the answer to the first question must be NO and reasonable belief in that the answer to the second question would also be NO. And "NO" in both cases because of the gulf that exists between professional and non-professional practices.

The Professional Engineer is defined by the Taft-Hartley Act and more elaborately by the conferees at the conference of the Engineering Societies of Western Europe and the U.S.A. (EUSEC) that met in Paris in September of 1953. Under the Act the professional engineer is one who having the education and experience aleady referred to is "engaged in work predominantly intellectual and varied in character," that involves "the consistent exercise of discretion and judgment," and is "of such a character that the output produced or the results accomplished can not be standardized." It clearly describes an individual whose economic lot is not susceptible to determination on a collectivized basis. The EUSEC conferees in Paris in 1953 merely clarify the statements about the Professional in the Act by adding that the "professional engineer is competent by virtue of his fundamental education and training to apply the scientific method and outlook to the analysis and solution of engineering problems"; that the professional has an education which will "make him capable of closely and continuously following progress in his branch of engineering science by consulting newly published work on a world-wide basis, assimilating such information and applying it independently"; that the professional is in a "position to make contributions to the development of engineering science or its applications"; and is thus able to "assume personal responsibility for the development and application of engineering science and knowledge, notably in research, designing, construction, manufacturing, superintending, managing and in engineering education."

It seems reasonable to believe that such individuals would seek an organization in which there is a "solidarity of interests, objectives, standards and responsibilities" (2) to use the words of Thomas A. Marshall, Jr., Secretary, Engineers Joint Council, but that they would be unfavorably disposed to the idea of collective bargaining to establish or improve their economic lot.

The EUSEC conferees do further service to all interested in recognizing the professional engineer by defining the Engineering Technician as one "who can apply in a responsible manner proven techniques which are commonly understood by those who are expert in a branch of engineering or those techniques specialy prescribed by professional engi-

neers," and who in performing their duties will have "supervision of the work of skilled craftsmen."

Can it be that we have failed to recognize the distinction between a professional engineer and an engineering technician? Between the professional and non-professional? Are we dead sure that professionals in the full sense of the Act and the definition of EUSEC are actually involved in collective bargaining?

Clear Distinction

In the spirit of Taft-Hartley there is a clear distinction between these groups. There is even a fine distinction between the professional intern and the non-professional. But this, and even the definitions of EUSEC regardless of their clarity, is all worthless if there is a lack of professional spirit in those that qualify as professionals. Perhaps engineering educators have failed in some measure and that the words of Sir Lionel Whitby at the First Conference on Medical Education in London last August are worth closer study. In his speech on "The Challenge in Medical Education" (3) he asks of the medical teachers if "those in control of medical education will really have the humility and courage to admit that all is not at its best in the best of all possible worlds, their worlds," and again "if those *who hold the shaping of the future in their hands will fashion it with vision and imagination so as to inspire the young man and woman to pursue the tasks of our great profession with a feeling of dedication to something greater than themselves.*" Is not this spirit of dedication needed if professionals are to give meaning and utility to their Unity Organization? Is not this spirit of dedication the cohesive element that will give them the stature they seek.

But while engineering educators may be to blame for having failed to inspire in their students a spirit of dedication to the professional cause let us not forget that others have a hand in molding the intern. It may be that the misuse of professionally trained personnel is equally responsible for this lack of professionalism in their conduct. Perhaps a re-appraisal of the duties of the professional will show that much now considered to be within the domain of the professional really falls within the province of the non-professional.

Such re-appraisals are not easy to make or once made to effectuate. But they are necessary if all concerned wish to taken another look at the reasons for professional (?) bargaining groups. Such re-appraisals may even affect the number of engineering schools now in existence. Such reappraisals will certainly affect the curriculum of the professional schools and bring into being a much larger group of institutions whose interests are with the engineering technicians.

Another look, and still another look at the reasons for professional (?) bargaining groups is urgently needed. The result of the many "looks" will not materialize overnight, or within the next five or ten years. But they are needed if we are to have the Professional Engineers that our country needs.

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Some Methods and Techniques Used by the Armed Services That Colleges Might Well Examine*

By CLYDE R. NICHOLS

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For the past several years we have been giving an ever increasing attention to such questions as:

1. How can we do a better job of teaching.
2. How can we encourage and help develop the more capable student? ASEE has several committees who are making some searching studies trying to find the answers. In this search may I suggest a few methods and techniques used by the Armed Services that Colleges might well examine. In trying to find how we can do a better job of teaching and how we can help the more capable student let us look at what the Armed Services are doing with:

1. Instructor training and preparation.
2. The use of supervisory check sheets.
3. Scheduling only one subject at a time.
4. Sectionalizing on the basis of ability.

The gigantic training effort necessitated by World War II is easy to recall. More than 18,000,000 service personnel were trained and over 2000 specialists schools were established. A very large instructional staff had to be assembled and trained. Virtually the only source of obtaining those new instructors was from the graduates of the various schools. The students who made the best grades were retained as instructors. How similar to the manner in which college instructors are chosen today and have been chosen for decades. Each Service School had to develop an INSTRUCTOR TRAINING program peculiar to its own needs and as best it could. As time went along specialists in educational methods, psychology, speech, and training aids, were brought in to develop those instructor training programs. By the end of WW II some excellent instructor training schools existed, and a few have been continued and improved to the very present. One of the better, if not the best, is the two weeks course in instructor training put on by the Armed School at Fort Knox, Ky. The Army sends men from all over the U. S. to take this course, and I have just returned from attending it. Instruction is given in the following subjects:

1. Principles of learning
2. Fundamentals of instruction
3. Presenting oral instruction
4. Speech techniques
5. Training Aids
6. Planning the lesson
7. The lesson plan
8. Presentation by the lecture, conference and demonstration methods
9. Questioning techniques
10. How to conduct a critique

* A paper presented to the Educational Methods and Electrical Engineering Divisions of ASEE at the annual meeting of the Society, held at the University of Illinois, Urbana, Ill., on 16 June 1954.

11. Test construction
12. The supervisory check sheet
13. Problems in organizing and administering an instructor training school

The Military and Naval Academies, the Command and General Staff College, the Army, Navy and Air Force War Colleges, and all the Service Schools operate very special instructor training courses during the summer for all newly assigned instructors. These include a course similar to the one at Fort Knox, followed by study, preparation of lesson plans, running laboratory exercises and preparing demonstrations and training aids in the actual course work or subjects in which they are to give instruction.

In 1930 I was hired by Purdue (on the basis of good grades) to report on September 15th. I actually reported on the first of September. The late Prof. C. F. Harding, then head of the E. E. School, asked why I was there so early? I told him I wanted to get a textbook and begin preparing the lessons I was to teach, and wanted to go into the laboratory and run the experiments so I would know what was going to happen when I told a boy to do something. He leaned back in his chair and said he had been head of the E. E. School 22 years and this was the first time this had ever happened, and he thought it was a pretty good idea. In the 24 years since, I am unaware of anyone reporting early for the same purpose, although I have not been in a position to know.

We all know that a high school teacher, or a grade school teacher, or even a kindergarten teacher has to have all sorts of special training to be qualified to teach. But how many of you ever heard of any special training required to be a college engineering instructor? If we want to improve instruction in colleges, isn't it about time we considered a few instructing techniques in addition to how well the instructor knows his subject? Can you imagine the effects on instruction if new instructors were hired on a 12-months basis for the first year, to begin in July with a training and preparation program similar to that at the Service Academies? What would a 10-day or 2-weeks methods of instruction course, followed by 6 to 8 weeks of specific study, preparation of lessons, running laboratory exercises and preparing demonstrations and training aids in the subjects the new instructor is going to teach, do to the quality of instruction in these subjects? And incidentally, if such employment could be had during the summer following graduation, might not colleges be in a more favorable competitive position with industry in securing potential instructor personnel initially? However, if budget limitations prevents the hiring of new instructors on a 12-months basis the first year, what is there to prevent us from bringing the new instructors together near the first of September for a 10-day or 2-weeks methods of instruction course? We have to pay them for the first part of September anyway—why not use this time to a better advantage?

Instructor Evaluation

Now let us turn our attention to the "Supervisory Check Sheet." All the Services are using some form of supervisory check sheet on every instructor in the service. If you have ROTC in your college you can check with them as to the specific form they use, and the attitude among the instructors about its use. The supervisory check sheet that is used at the Armored School at Fort Knox (shown below) consists of a cardboard printed on both sides. On one side we see the directions for using the check sheet; a place to list the instructor's major strengths; and a space to list the supervisor's (or observer's) recommendations for improvement. On the other side are eight elements (of good instruction) to be rated, with a number of subtopics under each element.

THE ARMORED SCHOOL
Fort Knox, Kentucky

NAME _____

SUPERVISORY CHECK SHEET

INSTRUCTOR _____ CLASS OR DEPT _____

TITLE OF LESSON _____ FILE NR _____

REPORT SUBMITTED BY _____ RATING _____

CRITIC _____ RATING _____

CLASS OR DEPT _____

DIRECTIONS: 1. Rate subtopics under Elements To Be Rated as follows:

\+ Plus for performance above average.

✓ Check for performance which is average.

\- Minus for performance below average.

2. Rate each Element To Be Rated on the Rating Scale by circling the number which best describes the over-all performance for that element. The numbers have the following meanings:

6. Outstanding
5. Superior
4. Excellent
3. Very Satisfactory
2. Satisfactory
1. Unsatisfactory

3. Write comments to justify your rating of each element of the lesson. List major strengths and make recommendations for improvement.

MAJOR STRENGTHS

RECOMMENDATIONS FOR IMPROVEMENT

In using this check sheet the subtopics will be rated by placing a plus mark in the box for performance above average; a checkmark in the box for performance which is average; and a minus sign for performance below average. Then the element as a whole is rated on the rating scale by circling the number (or using a checkmark along the scale) which best describes the overall performance for that element. The numbers along the scale have the meaning: outstanding, superior, excellent, very satisfactory, satisfactory, and unsatisfactory. Next, comments to justify the rating given each element is placed under each scale.

Where possible, observers experienced in methods of instruction, will be used to fill out the check sheet, with the objective of making a fair evaluation of the instructor's performance, and offering constructive suggestions for improve-

ELEMENTS TO BE RATED		RATING SCALE
INTRODUCTION		
Objective	☐	6 | 5 | 4 | 3 | 2 | 1
Reasons	☐	
Contact	☐	
Interest	☐	
EXPLANATION—DEMONSTRATION		
Organization Easy to Follow	☐	6 | 5 | 4 | 3 | 2 | 1
Clear Explanation of Points	☐	
Emphasis of Key Points	☐	
Material Vitalized	☐	
Transitions	☐	
Summaries	☐	
Demonstration	☐	
INSTRUCTOR QUALITIES		
Appearance & Bearing	☐	6 | 5 | 4 | 3 | 2 | 1
Poise & Confidence	☐	
Mannerisms	☐	
SPEECH TECHNIQUES		
Volume—Use of PA	☐	6 | 5 | 4 | 3 | 2 | 1
Rate	☐	
Fluency	☐	
Phraseology & Usage	☐	
Contact with Class	☐	
Force & Enthusiasm	☐	
Enunciation & Pronunciation	☐	
Gestures	☐	
USE OF TRAINING AIDS		
Selection of Aids	☐	6 | 5 | 4 | 3 | 2 | 1
Use of Aids	☐	
Use of Pointer	☐	
Smoothness	☐	
Blackboard Work	☐	
CLASS PARTICIPATION		
Student Participation	☐	6 | 5 | 4 | 3 | 2 | 1
Characteristics of Questions	☐	
Techniques	☐	
Answers to Student Questions	☐	
Application	☐	
Examination	☐	
DISCUSSION & CRITIQUE		
Questions Cleared Up	☐	6 | 5 | 4 | 3 | 2 | 1
Summary	☐	
Closing Statement	☐	
PREPARATION		
Command of Subject	☐	6 | 5 | 4 | 3 | 2 | 1
General Plan for Lesson	☐	
Material on Level of Class	☐	
Signs of Rehearsal	☐	
Timing	☐	

Assigned Length_____Min Time Start_____ Time End_____ Total_____Min

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ment. When an experienced observer is not available, the instructor's immediate supervisor or those higher up, make out the check sheet as best they can, but with the same objectives. And it does not take too long to develop to the point where a great amount of help can be given to the instructor, especially if he is a new one. The observer or supervisor never interrupts the class or instruction in any manner. Rather, a private after-action critique is held. This routine is followed until the new instructor becomes fairly confident and experienced. Afterwards, only an occasional visit is made to keep the instructor on his toes, or when the instructor requests a check be made in order to help him. When the instructor sees and studies the items and ratings and recommendations on the completed check sheet he realizes that it is all being done in order to help him improve, and he actually welcomes the visits of the supervisors. I have seen many new instructors request fellow instructors to monitor their work and make recommendations for improvement. However, they want a check sheet used, for it is specific and objective—they are not interested in opinions without foundation.

How many of us in the college teaching game have ever had a supervisor or a head of a department visit our classes in order to find out first hand how we are doing, or to offer constructive suggestions for our improvement? Many were the times during my first few years that I longed for someone to visit my classes in order that they might help me. I still would welcome a visit, although I am pretty well set in my ways now. How many of us have ever had rating sheets made out by fellow instructors that would help improve our methods and techniques? May I suggest the honest belief that the efficient use of supervisory check sheets will help improve the instruction of beginners no end, and that once the objective is understood, the beginner will actually request the supervisor to use the check sheet.

Techniques for the Capable Student

Now let us see if the Armed Services have any methods or techniques that are designed to help advance the more capable student? First, virtually all the Service Schools operate on the premise that more information and education can be accomplished in the minimum time by concentrating on one subject at a time. When several subjects are to be studied at the same school only one or two are taken concurrently. In the Coast Artillery School and the Antiaircraft Officer Candidate School where I worked two years, there were seven different subjects studied over a three months period. These were taken one at a time for periods of one to two weeks each. One of these, for example, was trigonometry, using a standard college text. The students went to class eight hours per day for five and one-half days. Approximately three hours each day was devoted to instructor presentation, and the rest was application and supervised study. Then there was three hours of study per night for six nights, with an instructor present to help when needed. Experience taught that more subject matter could be covered and more retained by this approach to a series of subjects. At West Point, where I taught four years, never more than two major subjects were scheduled concurrently. This same idea is used to a limited extent by those colleges that operate on the "quarter" plan. What do you think you could accomplish in a course if you met class for two or three hours each day and had a self-contained laboratory five days per week for three weeks? Especially, when there are no other subjects to divide your efforts and attention between? I believe I learned more in two weeks at Fort Knox about one subject than I have ever learned in a 3-credit graduate school course scattered out over 16 or 17 weeks and all mixed up with a lot of other courses at the same time. One wonders if some day some College may be brave enough to break with the

tradition of taking five concurrent courses per semester and schedule one subject at a time for five consecutive three-week periods? And incidentally, how much additional time would a student need to make up a single course failed somewhere along the line? And how long would he have to wait to begin the repeat of the course after he did fail it?

The second technique used to help the outstanding student is that of sectionalizing on the basis of ability. West Point and Annapolis have long been the outstanding examples of this technique. All students start on an equal basis. At the end of each four to six weeks they are sectionalized on the basis of their accumulated grades to that date. This is done throughout the entire four years. By the time they reach their junior and senior years they really have all the capable ones together in the top sections. The upper sections are given additional study assignments, employ more difficult and theoretical texts, and are required to make more extended investigations in the laboratories than are the lower sections. The most brilliant and fastest thinking faculty members are assigned as instructors of these upper sections. Experienced instructors recognized as being thorough and capable of instructing the "plodders" are assigned to the lower sections. It is found that this makes for the finest teamwork possible. No one is impatient of the other fellow for being too fast or too slow. The instructor is not above the level of some nor below the level of others. No one loafs and all are continually challenged to their capacity in order to remain in the upper sections. Could colleges and universities sectionalize on the basis of ability? With the myriad of curricula, courses, efficient utilization of laboratory facilities, and personal matters of individuals involved, it is questioned that too much could be done except at the beginning of each semester or quarter? But what have we done with the accumulative grade-point indices after the freshman year to date? This past semester at Purdue we had ten sections of second semester sophomores in Electrical Engineering with grades ranging from A to F in each of the ten sections. Would sectionalizing on the basis of grade-point indices enable us to better promote and develop the more capable along the lines of advanced theory, research and highly specialized training, faster and more thoroughly; and at the same time permit more attention to the generalized and vocational training of the slower group? Why does West Point, with its basic General Engineering curriculum of fundamentals, rank fourth in the Nation in the number of Rhoades Scholars? Why do their graduates come to our colleges and make the very top grades in our graduate schools?

Summary

In summary, in our search to improve our teaching, let us consider the possibility of:

1. Instituing instructor training courses for new instructors.
2. Beginning extensive use of supervisory check sheets.

And in trying to help develop the more capable students let us consider:

3. Scheduling only one subject at a time.
4. Scrutinizing more carefully the advantages to be gained by sectionalizing on the basis of ability.

Twenty-four years ago I had an honor student tell me that a new instructor wasn't worth a tinker's damn. I have heard some such remark at least once a year ever since. I heard a panel discussion in Chicago wherein each College in the Illinois-Indiana Section of ASEE was worrying about the quality of instruction received from the inexperienced instructors handling non-electrical courses. I suggest we have a REAL challange. And I for one, am going to try to meet this challange in a small way by attempting to develop an instructor training course for new engineering instructors, and sell them on the idea of using the supervisory check sheets.

Teaching Design by Motivation*

By LEE HARRISBERGER

Assistant Professor of Mechanical Engineering, North Carolina State College †

Design is generally regarded as an ability which must be learned by years of industrial apprenticeship. However, design can be taught. There are several basic ideas that may be used in an approach to teaching design. First, the student must become conscious of the value of the line of attack. Second, he must be trained to become critical, to challenge every idea, to be on the lookout for other ways, and to compare, weigh and discard. Third, he must be taught to make decisions—boil the ideas down. Fourth, he must be taught to coordinate all the influencing factors affecting or being affected by the design.

The first three years in engineering are devoted to fundamental concepts and rigorous exercise in the use of these concepts in problem situations. Somewhere in the fourth year the student should begin to learn to think in terms of whole problems—to begin to develop an analytical approach to an unknown situation which has no immediate answer nor even a real definition. But above all, he must begin to develop a mature engineering attitude with confidence in his capacity.

In the senior machine design course last year at the University of Utah, an experiment was conducted to test this approach—this philosophy for teaching a design course. The teaching motive was borrowed from Confucius: ". . . do not pull the student along, open the way but do not lead him to the place . . . let the students admire the excellence of other students."

The formal lecture sessions were separated in plan and action from the laboratory sessions. The lectures were designed to emphasize the importance of good design decision and rational analysis. Stress determination was not played up as the primary function of the designer. The attempt was directed toward developing in the student an attitude of awareness of the importance of all things in a complete engineering design.

The laboratory portion of the course was the crux of the whole new scheme. For one thing, it caused the lectures to "hit the nail on the head" for the student Most of the battle is won for the lecture instructor when the student has discovered how important it is for him to know what is being discussed. In the laboratory program an attempt was made to adhere to two fundamental goals in teaching: to generate within the student a burning enthusiasm, and to force the student to self-motivated activity. One is a function of the other. A student is a dynamo of self-motivated action when he becomes enthusiastic.

Enthusiasm seems to be a natural product of immaturity. Man from his childhood has a basic drive to seek new adventure and new experience. It is the motivator toward his maturity. Children are enthusiastic about everything new because it is a new experience and satisfies their urge to master new skills. The senior student is eager to have a try at doing some engineering on his own—try out his new skill. He wants to test his technical strength, and he enjoys the competition of his fellow students be-

* Condensed from a paper presented at the Rocky Mountain Section meeting, ASEE, at University of Utah.

† Formerly at University of Utah.

cause it serves to gauge this technical strength. Give him these two opportunities and his natural enthusiasm for the adventure is boundless.

Cut Them Loose

A system was devised to put the students on their own—cut them loose from the instructor's apron strings. They were given the adventure of a "solo flight." They were put in an environment of competitive engineering activity that forced them to rely entirely on their own capacity. They were given a challenge and their enthusiasm was amazing.

The class was divided into eight-man teams. Students of strong leadership ability were chosen by the instructor to be the "Chief Engineer" of each team. Each "Chief Engineer" chose his team by a system of "choose-up" so that each team would have its share of capable talent. These teams were designated as consulting engineering firms . . . they even chose a name for their company. Each company was to compete for acceptance of a bid proposal for a design published by a fictitious company in the East. The bid request outlined a need for a competitive design of a moderately complex product the fictitious company wanted to manufacture and market. The specifications outlined in the bid request were based only on what would attract a particular sales market. The students had nothing more to go on than general requirements for capacity, endurance, saleability, safety, and cost. No requests were made for a particular design, material, size, weight, or cost. The bid requested that the competitive proposal be in manuscript form including pictorial illustrations (assemblies and breakdowns in perspective), cost analysis, complete specifications, detailed stress analysis, and manufacturing specifications.

Each consulting firm was to prepare a complete bid on reproducing masters and provide a copy for each member of the class. After the bids were prepared, two engineers from industry and an M.E. staff member were invited as consultants to represent the company that called for the bids. Each student "Chief Engineer" had to present his firm's design before the whole class and the panel of consultants. Since all the competing consulting firms had copies of each bid, they had an opportunity to review the competitive bids and use their criticism of them as arguments for their own case. Thus, each group was faced with the critical and devastating evaluation of the other groups. The panel selected and rated the bids in order of merit.

Academic evaluation of the student's performance for a grade was based on three things: First, each student was required to hand in a personal preliminary design which was graded as one measure of the individual's design conception. These preliminary designs were then used by the chief engineer and his staff to develop the competitive design. The second portion of the grade was based on the instructor's evaluation of the individual performance of each man for his company in the preparation of the details of the final design. The third portion was based on how well the student's company placed in the bid competition.

Perform at High Level

Never has a group of students taken such a genuine interest in a class. Competition was terrific. This competition forced the students to perform at a level far higher than the instructor could ever demand. They took it upon themselves to search the periodicals for new information, to talk to manufacturers, and to search for and learn techniques for solving special stress situations.

Several important and valuable training devices can be noted in this new approach to the teaching of design:

1. It stimulated the student and motivated him to take it upon himself to make his own decisions and search for information he did not have. He had to rely on his own resources to dig out stress and design techniques that had never been covered

in any class he had taken—just as he will have to do when he gets out in industry.

2. It put him into competition with his fellows on a technical plane rather than on an academic plane. He had to compete by virtue of his capacity to use his background and resourcefulness rather than his ability to master an academic hurdle such as an examination or homework assignment.
3. It created an environment of real engineering activity. It forced him to make decisions as to what was important in the design. It forced him to accept and reject ideas on the basis of a number of considerations. It made him compromise, analyze and come to a mature decision.
4. It gave the student an engineering sense of proportion. He had to consult with manufacturers to get the sense of costs and practicability.
5. Above all, it gave him a respect for his background and his own ability to conquer in an area where he had no previous experience.

This experiment showed a lot of potential and it showed that this type of teaching can be difficult. The teacher is no longer just an explainer, the man behind the pulpit. He becomes an administrator of the independent activities of each student. It is quite easy to expound facts and grade problems and examinations. It is more difficult to be a promotor, the big personality, the supreme enthusiast. In this new role he must continually set the pace, create and maintain the positive point of view, and help the student overcome discouragement when the going gets rough. He must guide their enthusiasm in the direction of maximum attainment. He plays the role of the professional consultant.

Design is not an art—it is the act of putting a lot of related facts together and making decisions as to which facts are important. To teach design is to teach thinking, reasoning, and self-reliance. Motivation is the key to learning. Therefore, give the student a mature challenge and his natural enthusiasm will motivate him to learn the most difficult of all—the ability to reason.

In the News

The forthcoming retirement of William N. Carey as Executive Secretary of the **American Society of Civil Engineers**, oldest national organization of engineers in the country, has been announced at the organization's headquarters in New York. The retirement will take effect May 1, 1955.

Col. Carey, former Chief Engineer of the Federal Works Agency and former City Engineer of St. Paul and distinguished in many fields of civil engineering, will become Secretary Emeritus. He will be succeeded by William H. Wisely, of Champaign, Illinois.

Requirements for Engineering in the Communications Operating Field*

By H. I. ROMNES

Chief Engineer, American Telephone and Telegraph Company

Engineering in all areas have this in common—they are all creative activities. The engineer in research and development creates designs for new tools to provide new, better or cheaper communications. The engineer in manufacturing creates the methods for making these tools—converts paper designs and laboratory models to commercial products. Some of these products, for example, television sets, then are ready for the ultimate consumer, but others are used by the engineer in the operating field to create communication service.

I emphasize the creative aspects of the operating engineering job because I feel that, above all, education for engineers in the operating field should lay the foundation for original thinking. The purpose of engineering education should not be to train men to do things which have been done before. The improvements of the future, the new things for better living, will not come about by having engineers doing the same things repeatedly. In fact, the burden of routine repetition will dull the creative mind. Repetitive technical jobs can be done by technicians who are employed by the tens of thousands in the communications operating industry and trained by the industry or by technical institutes.

There are four additional points I would like to make about the nature of the engineering job in the communications operating field.

—It is very big. The operating branches of the Bell System alone have about 6000 engineering graduates who, in creating communication services, make use of the products of about 1800 engineers in development and research and 2500 in manufacturing. In addition there are many more communications operating engineers in such fields as audio and television broadcasting, domestic telegraph, overseas radio communications services, air, land and sea transportation and the newspaper field.

—It involves high stakes. For example, in the telephone industry alone, engineers are responsible for investing well over a billion dollars each year in new plant. Seeing to it that the existing plant is kept in good condition and is used well so as to give the most possible and the best possible service involves expenditures of another billion dollars each year.

—The rewards in job satisfaction and and monetary compensation for men of equal ability are as great in the communications operating field as in any branch of engineering.

—A second rater will be no more successful in the operating engineering field than he would be in research and development or manufacturing.

The impression I want to leave with you is that the education of engineers for the communications operating field should not be subordinated in your planning

* Presented at the Annual Meeting of ASEE, Electrical Division, University of Illinois, June 17, 1954.

of curricula for engineering education. You should not place all the emphasis on the training of the best undergraduates to be specialists in highly technical fields with the broad engineering education needed by engineers in the operating field reserved for the less capable. The operating field needs and provides rewarding careers for many of the very best engineering graduates.

Why Are Engineering Graduates Needed for Communications Operations?

An engineering education is a most valuable asset in a number of assignments in the communications operating industry.

In an industry so firmly rooted in complex technology, all levels of management including top management need a large proportion of men who have an engineering background. They need to have a good understanding of the technical devices, systems and phenomena involved in communications in order to make wise decisions in the conduct of the business. Fortune magazine recently surveyed the three highest positions in each of the 300 biggest U. S. industries and found that 45% of the men holding these positions had engineering training. In the communications industry the proportion is at least as great. You may say there cannot be much wrong with engineering education when it can produce graduates who carry such a large part of the leadership in industry. But I'm sure industry would get even better management if the planners of engineering college curricula would have these management aspects in mind.

Another group in the communications operating field who need engineering training are the men who make the long range fundamental plans for expanding and improving present communication services and for establishing new services. These are the people who are blazing the trails that will be followed on into the future. They guide the research and development engineers as to what is needed for the future and, of course, are guided by them as to what is possible. Engineering education can provide for them a thorough understanding of engineering fundamentals so they can deal intelligently with the highly technical devices and phenomena which are the building blocks for the systems of the future. But, in addition, engineering colleges should teach them objective and systematic methods of analysis, basic economic concepts and the fundamentals of effective written and oral presentations of engineering studies.

The detailed planning to carry out the long range fundamental plans for communications plant also requires a great deal of original thinking in a highly complex field. Most of this new plant is tailer-made to fit a particular situation—planning for it is not merely a matter of following a handbook. Engineers are needed to sketch out the broad outlines of the plans so that technicians can fill in the details and carry them out. The engineer in this area, therefore, must have the ability to supervise the work of others, as well as to originate the broad plans. How well he does the job can have an important bearing on costs and service since he deals with very large construction expenditures. For example, the project engineer for the job of converting a single manual telephone office to dial operation may deal with equipment costing several millions of dollars and the many decisions he makes as he goes along can have important effects on the cost and effectiveness of the job.

Still another activity of the engineer in the communications operating field is in the actual construction of new plant —the placing of coaxial cables across the country, or cables and amplifiers under the sea, or radio relay stations on mountain tops. This involves a thorough understanding of the complex plant for which he has the construction responsibilities. When he meets with unforeseen difficulties created by man or nature, he

needs to make changes on the spot if the job is to get done well, economically and on time. The proper decisions are facilitated if he has an engineering background which, in the case of the construction engineer in the communications field, goes beyond electrical phenomena into mechanical and structural fields. In addition to engineering know-how, he must know how to deal with people.

There is still another area in the communications operating field where an engineering education is of great value. This is in the day-to-day management of the communications plant. In the Bell System, for example, nearly a billion dollars a year is spent for the operation and maintenance of the plant. There is great opportunity for originality in this job. Again the engineer needs a good understanding of the technical fundamentals of communications plant. He must be cost and service conscious. He must know how to instill the desire to do the job well and economically in the dozens or hundreds of technicians carrying out under his direction a wide variety of highly technical tasks under a wide variety of conditions.

What Should Engineering Education Provide for the Communications Operating Field?

Throughout my talk I have emphasized the importance of originality and creative thinking because I believe that that is a prime requirement for an engineer in the operating field (as it also must be in research and development and manufacturing). Equally I have tried to point up the fact that most of the work in the operating field that needs men with engineering training is of a supervisory or management nature. There are only a few positions in the operating field that will provide real job satisfactions for capable men with engineering degrees that do not ultimately involve supervision of others and working in close cooperation with others.

Education for the engineer in the communications operating field, therefore, should furnish him with the basic knowledge which will be helpful to him in creative thinking pointed toward ever more and better communication service at increasingly favorable costs and in managing men and money toward this end. It seems to me this should include:

1. An understanding of the fundamentals of science and engineering with emphasis on physical rather than mathematical concepts.
   —it is important to develop an understanding of physical phenomena but knowledge of particular devices or techniques is of value only as examples of the application of phenomena.
   —mathematics is of importance as a tool for understanding and explaining the physical phenomena but can be subordinated to that purpose.
2. Emphasis on electrical (including electronic) principles but for the operating field basic chemical, mechanical and structural principles also should be well covered.
3. Objective and systematic analysis of engineering problems.
   —the place for approximate versus exact analysis should be brought out.
   —a good concept of probability and sampling theory is a great help in analysis of operating problems.
4. A better-than-average understanding of costs and economic principles as applied to engineering planning.
   —a dollar spent in the future carries less weight than a dollar spent today.
   —initial cost is only part of the story; annual charges over a period may be even more important.
   —depreciation must be understood and allowed for adequately.

—judgment must be applied to the results of economic studies in reaching final decisions: the cheapest plan is not always the best engineering answer.

—the importance of doing the overall job so as to produce the earnings which a business needs to be healthy and to be able to make the investments required to provide "the better things for better living" which the public wants.

5. The principles of effective oral and written presentation of the results of engineering studies and plans.
   —needed to "sell" new ideas to the managers of the business and to direct technicians in carrying them out.
6. Human relations—working with and supervising others—knowledge of how to share and how to motivate.
   —in the operating field, the most successful engineers are not lone workers or specialists but members of a team and often team managers.
   —the times require that the manager in business know about people as well as about things—today he spends more and more of his hours on human problems.
   —there are many indications that the typical engineer is not at his best in providing the participation and motivation for subordinates which leads to high morale.
   —engineering colleges have an important responsibility in providing the background which will help their graduates in handling the human problems associated with management.

I believe all these things can be adequately covered in a 4 or 5 year college course by putting more emphasis on principles and less on techniques and specific applications. The latter can best be gotten on the job—in fact, it is the job of the engineer to create them.

College Notes

Construction has begun on the new half-million dollar engineering building at **Bradley University** in Peoria, Illinois. The new building is expected to be ready for the new school year opening 1955. It will adequately provide for an enrollment of 600 engineering students.

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January 31–February 11, 1955
Engineering and Management Course
University of California, Los Angeles

This is a two-week course for executives, supervisors, engineers, industrial analysts, cost accountants, and other line and staff personnel. Each student selects his program of study from thirty-five classes in subjects ranging from production management, motion and time study, quality control, and leadership, to mathematical programming, electronic data processing, and automation. The classes will be taught by members of the **University of California**, Los Angeles staff augmented by fifteen key men from industry. Early morning instruction in public speaking is optional. The $300 fee includes the cost of texts and course materials, ten luncheons, and three dinners. For information write to:

Edward P. Coleman, Coordinator
Engineering and Management Course
College of Engineering
University of California
Los Angeles 24, California

The Allison Program of Summer Employment for College Professors

By M. D. ADAMS

Associate Professor of Physical Sciences and Assistant Head, Technical Institute, Purdue University

To the Editor of *The Journal of Engineering Education:*

Several articles have appeared in the JOURNAL recently regarding summer employment for engineering educators in industry. Most of these opportunities have usually been considered in relation to the engineer members of the instructional staffs. The following letter represents an evaluation of my own experiences in such a program from the viewpoint of the non-engineer teacher. This summary was prepared originally for the Allison Division of General Motors in Indianapolis, Indiana, where I have been employed during the summers of 1953 and 1954.

August 24, 1954

Allison Division
General Motors Corporation
Indianapolis, Indiana

No one in engineering education today questions the desirability of industrial experience for the engineer members of engineering instructional staffs. In fact, it is generally accepted as a necessity. But for the non-engineer instructor (such as I) the need for such experience has not been so clearly recognized. Even when recognized as desirable, the opportunity for worthwhile experience close to the field of engineering has been greatly restricted. As a consequence the mathematics, physical science, social science, and communications instructors, or others in engineering colleges have often had an inadequate or erroneous concept of how their instruction can best be adapted to meet the educational needs of engineering students. Such lack of understanding—often associated with strictly academic backgrounds and viewpoints—has sometimes led not only to misunderstandings but lack of sympathy for the objectives of engineering education itself.

As a non-engineer, working in Engineering Education, I wish to thank and commend Allison for extending the summer employment program for College Professors to include other than the engineer members of the instructional staff. It is my belief and experience that the close associations with practicing engineers in a typical industrial situation will prove as valuable to the nonengineer instructor as to the engineer. My experience in technical writing leads to the belief that many other non-engineers could gain valuable engineering experience and association in that field while at the same time rendering useful and needed services to industry.

Effects of Allison Work Experience on Me

Due to my two summer employment periods here, I have:

1. Seen that industry (at least at G.M.) recognizes its position and obligations in the task of engineering education and is ready and willing to work in cooperation with the engineering schools in every way.

2. Seen that the great range of specializations, and rapid changes in indus-

trial procedures have made it mandatory that the curricula of engineering colleges deal largely in the fundamental concepts, basic skills, and universal attitudes upon which engineering is based. These fundamentals ensure delivery of a suitable candidate to industry for efficiently and effectively taking full advantage of their highly specialized on-the-job training programs.

3. Seen that engineering usually represents team work of the highest order and that a basic requirement in all engineering education is the development of the necessary skills, and personal attitudes and traits so important for satisfactory team work.

4. Seen that in industrial practice various forms of communications have been developed to a place of great importance, and that facility in written, oral, graphic, and mathematical communications of ideas is a basic requirement of engineering education.

5. Seen that industry has recognized the great importance of the personal elements, of developing men of integrity and high moral character with a sense of human dignity and worth. (The friendly and helpful cooperation extended to me by Allison employees, and the high morale on the part of all are evidence of the degree of success in this direction at Allison.)

6. Learned a vast number of applications of engineering and scientific principles that will serve to enrich my own teaching.

7. Learned, with new emphasis: that technological education and training consist of more than producing engineers; that there is a need for all levels and degrees of skills and knowledge usually acquired through vocational schools, technical institutes, four-year colleges, and graduate schools of science and engineering; and that the highest degree of success will result only when all these educational systems work together with one another and with industry in effectively meeting the needs of a civilization that has become highly dependent upon technology.

What Have Been the Direct Benefits of My Services to Allison?

1. By choosing to specialize in one very narrow field of engineering (Disk Vibrations in Turbojet Aircraft) it was soon possible to make a limited contribution to certain engineering practices.

2. There does exist, and has for years a shifting of engineering education emphasis toward a more scientific base and away from the over-stressing of engineering as an "Art." By approaching and solving a few problems from the scientific viewpoint, with emphasis on basic principles, I may have served to demonstrate in a modest way that such approaches were powerful engineering tools. Conversely by observing the extent to which engineering as an art can and has produced results, my own thinking and appreciation have been shifted in this direction from an over-emphasis of the rigorous scientific and mathematical approach. This tendency to shift toward common ground in this respect is undoubtedly good for all concerned.

3. A fair degree of success in unearthing valuable new information through the library in connection with disk vibration, may have served to give this fundamental step in research a more important position in the minds of test engineers with whom I have been associated here.

What Have Been the Long Range Benefits of My Services to Allison?

The long range benefits to Allison depend upon what I do with the knowledge, skills, and attitudes which I have acquired here. Any such benefits are based on the sound premise that whenever technological education improves or is benefitted that Allison, together with all industry, will ultimately benefit in one way or another.

As a counselor, teacher, supervisor, and administrator, working directly and indi-

rectly through and with many instructors and many hundreds of college students and high school students, the opportunity certainly exists for attitudes, ideals, and knowledge acquired by me at Allison to be multiplied many-fold in its ultimate influence on many.

Recommendations

1. Broaden the base of the summer faculty to include at least 50% of engineers but a sampling of all the other general fields associated with technological education, to broaden the viewpoint of all.

2. Extend the seminar idea to include weekly meetings with unified, cooperatively-planned programs. (This summer's activities were far superior to those of last because of that.)

3. Publicize the program and the opportunities through the Journal of Engineering Education, as well as through the Deans of Engineering Colleges.

4. Follow through with letters to Deans, Department Heads, etc., acknowledging the participation of members of their staff, pointing out that military restrictions made publicizing on their part impossible for many worthwhile engineering and scientific contributions.

5. Consider a broader policy that might be called "Cooperative Education-Extended to Faculty." In such a program exchange agreements between college and industry might be worked out to bring the Industrial employed Engineer to the college for a semester and the Professor into industry. (This does not necessitate nor imply a specific exchange of jobs.) Such a program might be established on a small scale with top flight Professors and Engineers and extended if its success should warrant this action.

New Members

ALI, MIR M., Chief Instructor in Power, Pakistan Technical Institute, Pakistan. H. R. Beatty, W. E. Marsh.

ALLEN, THEODORE, JR., Associate Professor of Mechanical Engineering, University of Wichita, Wichita, Kansas. M. H. Snyder, J. W. Dunn.

BONDURANT, BYRON L., Head, Department of Agricultural Engineering, University of Maine, Bangor, Maine. R. B. Rhoads, F. W. Peikert.

BONELL, JOHN A., Associate Professor of Civil Engineering, University of Nevada, Reno, Nevada. H. B. Blodgett, J. R. Van Dyke.

BRICKNER, JOSEPH L., Instructor in Engineering, Central Technical Institute, Kansas City, Mo. V. E. Vilander, C. V. Curtis.

BROWN, HAROLD H., Instructor Central Technical Institute, Kansas City, Mo. N. E. Vilander, C. V. Curtis.

CARTER, ROBERT J., Associate Professor, State University of New York, Albany, N. Y. F. E. Almstead, W. H. Branch.

CHASE, EDWARD L., Staff Assistant, Engineering Training Department, Bell Aircraft Corporation, Arlington, Texas. R. W. Reynolds, C. E. Knott.

COLEMAN, THOMAS C., Assistant Professor of Civil Engineering, Northeastern University, Boston, Mass. W. C. White, W. T. Alexander.

COOK, EVERETT L., Instructor in Aeronautical Engineering, University of Wichita, Wichita, Kansas. M. H. Snyder, J. W. Dunn.

DALE, ALVIN C., Associate Professor of Agricultural Engineering, Purdue University, Lafayette, Indiana. G. E. Spencer, J. L. Waling.

DE MARCHE, JOHN M., Assistant Professor of Civil Engineering, Louisiana State University, Baton Rouge, La. W. P. Wallace, L. J. Lassalle.

DUPRE, EDMUND J., Associate Professor of Chemistry, New Bedford Institute of Textiles and Technology, New Bedford, Mass. J. E. Foster, L. R. Coombs.

DURBETAKI, PANDELI, Instructor in Mechanical Engineering, University of Rochester, Rochester, N. Y. L. D. Conta, R. F. Eisenberg.

EDDY, ELWIN H., Col. USA Ret., Instructor in Mathematics and Engineering Mechanics, General Motors Institute, Flint, Mich. H. M. Dent, C. E. Stout.

EDWARDS, GAIL P., Professor of Chemistry and Civil Engineering, New York University, New York, N. Y. W. E. Dobbins, James Michalos.

ELWES, EDGAR M., Coordinator of Research, Instituto de Investigaciones Industriales, Monterrey, Sucursal J., Nuevo Leon, Mexico. B. R. Teare, Jr., J. W. Graham, Jr.

ETEMAD, GHOLAM A., Assistant Professor of Mechanical Engineering, University of Buffalo, Buffalo, N. Y. R. E. Shaffer, P. E. Mohn.

FENAUX, LOUIS E. F., Associate Professor of Chemistry, New Bedford Institute of Textiles and Technology, New Bedford, Mass. J. E. Foster, L. R. Coombs.

GITZENDANNER, FRED A., Associate Director, Engineering Research Department, Standard Oil Company (Indiana), Chicago, Ill. J. E. Crouch, Arthur Lesser, Jr.

GONSALVES, LENINE, Instructor in Engineering, New Bedford Institute of Textiles and Technology, New Bedford, Mass. J. E. Foster, L. R. Coombs.

GONZALEZ, MANDRY F., Chairman, Mechanical Engineering Department, University of Puerto Rico, Mayaguez, Puerto Rico. Luis Stefani, C. Calor-Mota.

GOULDTHORPE, HUBERT W., Manager, Engineering Personnel Department, General Electric Company, New York, N. Y. A. M. Anderson, C. E. Watson.

HADFIELD, ROBERT W. M., Assistant Professor of Mechanical Engineering, University of Bridgeport, Bridgeport, Conn. Raymond Petrie, W. P. Bergren.

HALE, HARRY P., Assistant Professor of Mechanical Engineering, Wayne University, Detroit, Mich. Glenn Howell, Donald Perkins.

HANSEN, HUGH J., Assistant Professor of Agricultural Engineering, Purdue University, Lafayette, Ind. G. E. Spencer, E. W. Comings.

HOCKADAY, O. S., Director of Personnel Relations, Texas Electric Service Company, Fort Worth, Texas. W. R. Woolrich, V. L. Doughtie.

HOPE, HERBERT W., JR., Assistant Professor of Engineering, University of Bridgeport, Bridgeport, Conn. W. P. Berggren, R. W. Petrie.

JOHNSON, CHESTER M., Instructor in Industrial Engineering, University of Wichita, Wichita, Kansas. M. H. Snyder, J. W. Dunn.

JOHNSON, HEBERT E., III, Assistant Professor of Mechanical Engineering, University of Wyoming, Laramie, Wyoming. E. J. Lindahl, H. T. Person.

JORDAN, VIRGIL L., Technical Instructor, Central Technical Institute, Kansas City, Mo. N. E. Vilander, C. V. Curtis.

KESSLER, RICHARD, Instructor in General Engineering, Purdue University, Lafayette, Ind. W. J. Luzadder, J. H. Porsch.

KOLUPAILA, STEPONAS, Associate Professor in Engineering, University of Notre Dame, Notre Dame, Ind. M. O. Peach, H. E. Ellithorn.

KUKEL, JOSEPH, Assistant Professor of Electrical Engineering, University of Southern California, Los Angeles, Calif. G. T. Harness, R. E. Vivian.

LAPAN, JOHN W., Instructor in Structural Engineering, Hudson Valley Technical Institute, Buffalo, N. Y. O. V. Guenther, J. L. DeLee.

LAUBENFELS, C. R., Instructor in Engineering, Los Angeles City College, Los Angeles, Calif. J. W. Hazen, A. H. Repsha.

LEVY, MARTIN J., Assistant Professor of Engineering, University of Bridgeport, Bridgeport, Conn. R. W. Petrie, W. P. Berggren.

LILJEDAHL, JOHN B., Assistant Professor of Agricultural Engineering, Purdue University, Lafayette, Ind. G. E. Spencer, A. R. Spalding.

LONGWELL, WILLIAM F. M., Professor of Civil Engineering, Merrimack College, Andover, Mass. J. H. Crawford, A. H. Holt.

LUNSFORD, JESSE V., Assistant Professor of Civil Engineering, Washington State College, Pullman, Wash. G. H. Dunstan, J. H. McLerran.

MAHROUS, HAROUN, Associate Professor of Electrical Engineering, Pratt Institute, Brooklyn, N. Y. C. C. Carr, M. L. Hashmall.

MAS, SOERONO, Mechanical Engineer, Indonesian State Railway, Jakarta, Indonesia. H. H. Armsby, Arthur Bronwell.

MCCARTY, WALTER T., Senior Instructor in Mechanical Technology, State University of New York, Canton, N. Y. R. W. Miller, Peter Nevaldine.

MCMULLEN, CHARLES W., Assistant Professor of Electrical Engineering, Northwestern University, Evanston, Ill. R. W. Jones, Arthur Bronwell.

MERRITT, CROFT S., Instructor in Industrial Engineering, Ohio State University, Columbus, Ohio. P. N. Lehoczky, G. B. Carson.

MOORE, JAMES M., Instructor in Industrial Engineering, Cornell University, Ithaca, N. Y. Andrew Schultz, Jr., M. W. Sampson.

MORUZZI, ROMEO L., Assistant Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. T. H. Morgan, G. E. Stannard.

MURRISH, CHARLES H., Assistant Professor of Electrical Engineering, Clarkson College of Technology, Potsdam, N. Y. A. R. Powers, Chester Russell.

NELSON, ROGER H., Assistant Professor of Civil Engineering, State College of Washington, Pullman, Wash. E. G. Ericson, C. L. Barker.

NIELSEN, HERLUF P., Professor of Mechanical Engineering, University of Southern California, Los Angeles, Calif. R. E. Vivian, G. T. Harness.

PERKOWSKI, NAPOLEON, Instructor in Industrial Engineering, University of Southern California, Los Angeles, Calif. H. H. Grant, R. E. Vivian.

ROMER, IRVING C., JR., Instructor in Mechanical Engineering, Northwestern University, Evanston, Ill. A. B. Cambel, R. L. Young.

SEAMANS, DAVID A., Instructor in Electrical Engineering, State College of Washington, Pullman, Wash. E. G. Ericson, R. J. Knox.

SHARP, HENRY, Professor of Mathematics, U. S. Coast Guard Academy, New London, Conn. J. B. Hoag, R. J. Perry.

SHEHEEN, ALEXANDER T., Instructor in Ceramic Engineering, New York College of Ceramics, Alfred, N. Y. R. M. Campbell, W. J. Sutton.

SHELDON, HERBERT E., Technical Employment Representative, Bell Telephone Lab-

oratories, Inc., New York, N. Y. H. P. Smith, R. A. Deller.

STRANDH, ERNST S., Civilingenjor—M. of Sc. El. Eng., Association of Swedish Engineers and Architects, Stockholm, Sweden. Thorndike Saville, L. E. Grinter.

TAYLOR, JOHN W., Manager, College Department, McGraw-Hill Book Co., Inc., New York, N. Y. K. I. Zeigler, E. E. Booher.

TINKHAM, HOWARD C., Assistant Professor of Mechanical Engineering, New Bedford Institute of Textiles and Technology, New Bedford, Mass. J. E. Foster, L. R. Coombs.

TSAO, CHING H., Assistant Professor of Civil Engineering, University of Southern California, Los Angeles, Calif. H. G. Conley, D. M. Wilson.

UHL, VINCENT W., Associate Professor of Chemical Engineering, Villanova University, Villanova, Pa. R. E. White, J. S. Morehouse.

WILCOX, MILTON L., Assistant Professor of Electrical Engineering, University of Notre Dame, Notre Dame, Ind. H. A. Foecke, H. E. Ellithorn.

WIMMERT, ROBERT J., Instructor in Industrial Engineering, Purdue University, Lafayette, Ind. J. H. Greene, H. H. Young.

WOOD, FRED M., Instructor in Engineering Drawing, Tufts College, Medford, Mass. P. H. Hill, Jr., G. A. d'Amato.

WOODS, ANSON T., Instructor in Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Okla. R. E. Venn, J. H. Boggs.

WYMAN, HOLLIS J., Instructor in Mechanical Engineering, Franklin Technical Institute, Boston, Mass. B. K. Thorogood, W. H. Perry, Jr.

209 new members elected this year

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 17, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Brooklyn Polytechnic Institute	Dec. 4, 1954	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	April 2, 1955	M. M. Jones, University of Missouri
National Capital Area	Catholic University	Oct. 5, 1954	J. C. Michalowicz, Catholic University
New England	Massachusetts Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	A.F. Inst. Wright	Sept. 17–18, 1954	K. F. Sibila, University of Akron
	University of Akron	May 7, 1955	
*Pacific Northwest	Oregon State College	Spring, 1955	M. L. Jackson, University of Idaho
Pacific Southwest	University of California, Berkeley	Dec. 28–29, 1954	B. M. Green, Stanford University
Rocky Mountain	Colorado A. & M. College	April 16, 1955	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9 1955	V. L. Doughtie, University of Texas
Upper New York	Cornell University	Oct. 22–23, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

* **No Date Set.**

Young Engineering Teachers' Paper Contest

RULES

Eligibility: Members of ASEE who are not over 35 years of age (their 36th birthday must not be before June 1, 1955).

Awards: First prize $200—Second prize $100.
Honorable mentions as determined by the Judging Committee.

Presentation of Awards: The awards are known as the "President's Awards." They will be presented to the recipients by the President of the Society at the Annual Banquet at Pennsylvania State University, June, 1955.

Subject: Papers should deal with some constructive phase of improvement of engineering education. Participants are encouraged to use their own judgment in selecting appropriate subject matter.
The following are suggestions of possible subjects:

1. Professional development of the Young Engineering Teacher.
2. How should the student be helped to learn to deal with situations that are new to him, on his own initiative and with well-ordered professional thinking?
3. To what extent should modern physics be included in the engineering curriculum and how should this be done?
4. What areas of physics, chemistry, mathematics and biology not now taught in engineering curricula are likely to be translated into significant engineering practice in the next 25 years and how should this influence present curricula?
5. To what extent and in what manner should undergraduate instruction acquaint the engineering student with the methods of research and with recent research developments in engineering and closely allied sciences.
6. What should be taught of the art of engineering as contrasted with its science?
7. What basic science, mathematics and communication principles and skills can best be taught by separate department staffs and what part by integration into engineering courses?
8. What can be done in college to prepare the young engineer to continue to learn after his formal education is ended?
9. How should non-major courses in engineering such as electrical engineering for non-electricals be planned as to content and method?

Length of Paper: Not to exceed 2500 words.

Submission of Entries: All entries should be submitted to the Chairman of the ASEE Section in which the member resides before March 1, 1955. Names and school affiliations of Section Chairmen are published each month on the page in the Journal of Engineering Education designated "Section Meetings." Papers submitted in the contest last year or in other contests are not eligible for this year's contest.

Judging: Each Section of ASEE will appoint a Judging Committee to select the best paper from the Section. This paper will be submitted to the ASEE Secretary before April 1, 1955.

The winning papers from the various ASEE Sections will be submitted to a Final Judging Committee for the final selection.

Here is an opportunity to gain national distinction. Good luck!

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 1, 1955 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(In Charge of General and Regional Activities—two years)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

Do You Know—

► The Executive Board, at a meeting on January 13, 1954, elected as the new secretary of ASEE, Professor Leighton Collins. Professor Collins is Professor of Theoretical and Applied Mechanics at the University of Illinois. He is currently a member of the General Council, representing the Engineering Mechanics Division and has been active in ASEE affairs for a number of years. He was chairman of the Housing Committee for the Annual Meeting at the University of Illinois last June. Professor Collins succeeds Professor A. B. Bronwell, who has been appointed President of Worcester Polytechnic Institute beginning February 1, 1955.

The ASEE headquarters will move to the University of Illinois about February 1. The transition problems are being worked out and the present Secretary will provide every assistance possible in the months ahead to effect a transition.

After February 1, please address all ASEE correspondence to

Professor W. Leighton Collins
American Society For Engineering Education
University of Illinois
Urbana, Illinois.

In order to handle the selection of a new Secretary as democratically and expeditiously as possible, the President of the Society invited the Deans of all engineering colleges throughout the country to submit their nominations for the new Secretary. Invitations were also sent to Members of the General Council inviting them to send in nominations. The Executive Board met twice to sift the candidates and the President of ASEE and Secretary made several trips to institutions to explore facilities available. A substantial number of requests from engineering deans and Council members indicated preference for the Middle West as a location for the Society headquarters, since this is close to the center of the ASEE population.

► The Division of Relations With Industry will hold its annual College Industry Conference at Des Moines, Iowa, March 1 and 2, 1955. The theme will be "Current Problems Facing the Engineering Profession." All ASEE members and industrial people interested in engineering education are cordially invited to attend.

► Two Summer Schools have been authorized by the Executive Board for the Summer of 1955. These include a Summer School sponsored by the English Division and one sponsored by the Chemical Engineering Division. Both Summer Schools are being planned by their respective Divisions to present outstanding programs for teachers in these fields. They will be scheduled so as to be coordinated in time sequence with the Annual Meeting program of these two divisions.

► Again may we state proudly that our banquet speaker for the Annual Meeting this year will be the Honorable Charles Wilson, Secretary of Defense. Vice President Webster Jones at Carnegie Institute was instrumental in getting Mr. Wilson to accept this appointment.

► The Divisions and Committees of the Society are actively at work planning their annual meeting programs. From the vigorous reports of activities which we are receiving, we can predict one of the outstanding Annual Meeting pro-

grams of all times. You will definitely want to reserve the dates, June 20–24, and plan to bring the family for a profitable meeting and a pleasant vacation. There is no better vacation land in the country than the scenic mountains of Pennsylvania around State College, Pennsylvania.

► Proposals have been submitted to the National Science Foundation for two conferences and a Summer Institute. The Summer Institute will deal with thermodynamics as viewed from the vantage point of the physicist, the chemist, the chemical engineer and the mechanical engineer. Its objective is to bring together the widely divergent methods of approach and to explore the possible common ground in handling these subjects. This is one area where cross fertilization of different viewpoints might yield very substantial returns in terms of improvement of subject matter for teaching purposes. A closed conference of leading authorities in this field will be held at Purdue University. This will be followed by a conference open to ASEE membership either prior to or following the ASEE Annual Meeting at Pennsylvania State University.

One of the two conferences would deal with the coordination of subject matter in electricity and magnetism at the sophomore and junior levels, as taught by physics and engineering departments. There has always been a very substantial overlap in subject matter and it seems that better coordination here might achieve substantial returns in terms of better utilization of time. A closed conference at Lehigh University on February 14–16, 1955, of leading physics and engineering educators will provide material for the ASEE Annual Meeting Program.

A similar conference dealing with the teaching of mechanics at the sophomore and junior levels, looking toward a better coordination of subject matter between physics and engineering departments, is contemplated to be held at New York University. This conference will be the basis of joint meetings of the Physics and Engineering Mechanics Divisions. Proposals for the Summer Institute in thermodynamics and the above two conferences have been submitted to the National Science Foundation for financial support.

► Again may we remind you that the annual Mid-winter meeting of the Engineering Drawing Division is scheduled for January 27–29, 1955, at the University of Tennessee. A challenging three day session of technical papers and inspection trips, including a trip to Oak Ridge National Laboratories is being planned.

► The papers presented at the Solid State Physics Summer Institute, held at Carnegie Institute will be published in book form by John Wiley and Sons. An announcement will be published in the Journal when they are available. Also the papers presented at the Northwestern University conference on Nuclear Science in Engineering Education will be either published in separate book form or appear as a supplement in the Journal of Engineering Education.

► This is my last "Do You Know" column before moving on to Worcester Polytechnic Institute. May I express my hearty appreciation for the wholehearted cooperation which I have received from the officers and members of ASEE during the past eight years. It has been an exceedingly busy time, but packed with unforgettable experiences and pleasant associations. I look forward to continued active participation in ASEE in the years ahead.

Will see you at the Annual Meeting.

ARTHUR BRONWELL

The Pennsylvania State University

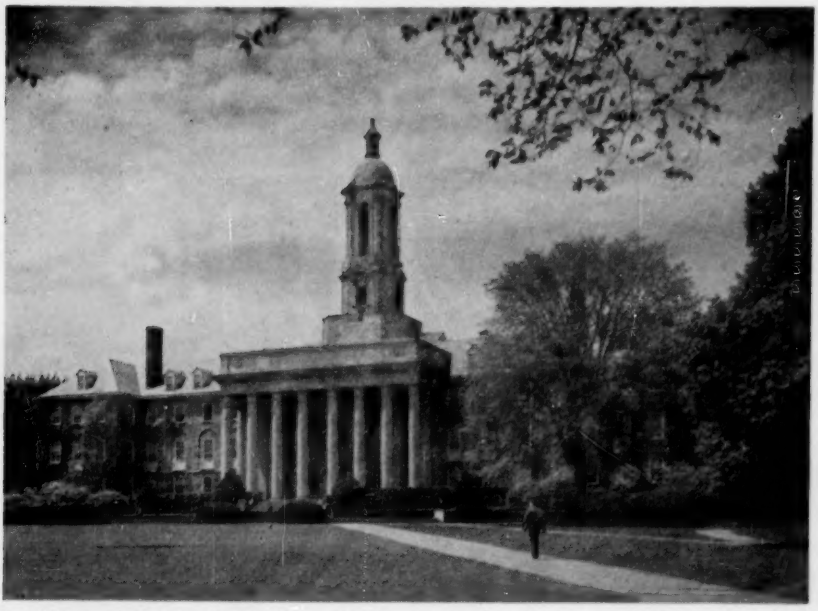
The Pennsylvania State University, where the American Society for Engineering Education will meet from June 19 to 24, will be in the midst of its Centennial Celebration when the meetings open.

The Centennial will be inaugurated with a birthday party on Feb. 22, the 100th anniversary of the granting of the charter; will bring President Dwight D. Eisenhower to the campus to deliver the Commencement address on June 11; and will terminate later in the year with a conference on higher education.

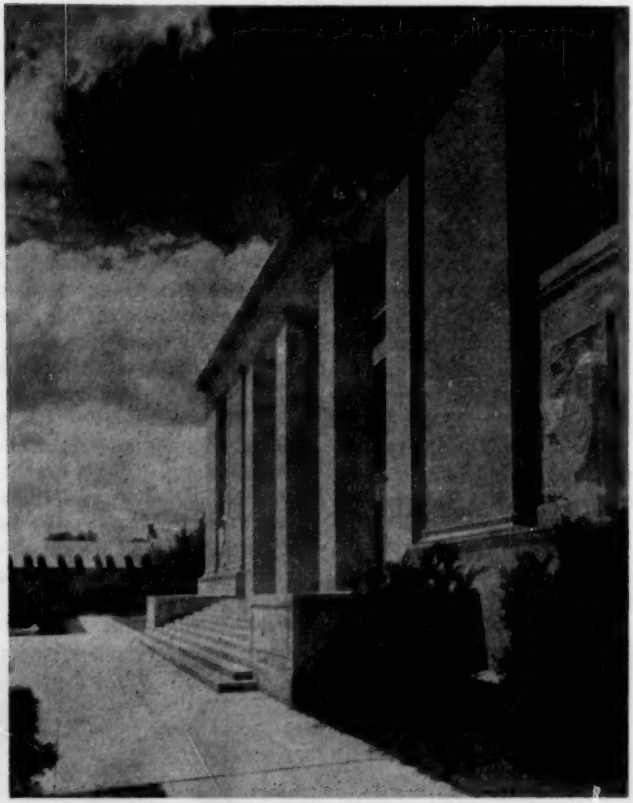
Originally chartered by the Pennsylvania Legislature as The Farmers' High School of Pennsylvania, the institution opened its doors to 69 students in February, 1859, and 119 had enrolled before the end of the year.

These students ate, slept, and went to class in a still-incomplete five-story building—the first Old Main. There were just four faculty members.

In the words of the charter of the institution, it was designed to give young men "a knowledge of the English language, grammar, geography, history, mathematics, chemistry, and such other branches of the natural and exact science as will conduce to the proper education of a farmer." This practical type of instruction marked a new concept of education.



OLD MAIN, administration building, is the center of activities on the Pennsylvania State University campus. The original building was constructed nearly 100 years ago, then replaced in 1929–30 by this structure.



FRED LEWIS PATTEE LIBRARY at the Pennsylvania State University was built in 1938 and recently was greatly expanded.

On May 1, 1862, the institution was renamed The Agricultural College of Pennsylvania, a name which recognized that its work was of collegiate level. Two months later, on July 2, President Abraham Lincoln signed the Morrill Land-Grant Act of Congress. This provided for granting public lands to the states which would use the income from them to establish institutions of higher learning where "the leading object shall be, without excluding other scientific and classical studies and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts . . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life."

To a large extent this was already the objective of The Agricultural College of Pennsylvania. Less than a year later, on April 1, 1863, the Pennsylvania State Legislature declared that the Morrill Act "is hereby accepted by the State of Pennsylvania with all its provisions and conditions and the faith of the State is hereby pledged to carry the same into effect." The Legislature then designated Penn State as the Land-Grant College of the Commonwealth.

The College enlarged the scope of its instruction to include the "mechanic arts" and other subjects, admitted a few women

students, and gradually increased its enrollment and enlarged its physical plant. In 1874 it was renamed The Pennsylvania State College, the name it was to be known by for the next 79 years.

In 1953, the name was changed to The Pennsylvania State University. The institution had been a university in fact, if not in name, for many years. Its Graduate School had been established in 1922, but graduate work had been offered earlier.

Today, The Pennsylvania State University offers 59 curriculums, many of which have several options, through the following undergraduate colleges: Agriculture, Business Administration, Chemistry and Physics, Education, Engineering and Architecture, Home Economics, The Liberal Arts, Mineral Industries, and Physical Education and Athletics.

Besides resident instruction, the University has two other main functions: extension and research. Its extension program offers class instruction, correspondence instruction, and informal instruction throughout the State. Its research program, which began with a few dollars spent on nursery stock, has developed into one which costs more than $6,000,000 annually.

Thus the University grew from an original enrollment of 119 to a student body of 14,271 in the fall of 1954; from a faculty of 4 to a resident instruction faculty of 1400; from an educational program which offered 40 courses to one which offers more than 3000; from a physical plant of one building with facilities for 400 students to a physical plant of 140 buildings valued at $68,000,000; from an institution which granted 11 degrees in 1861 to one which has granted a total of 55,868 degrees since the founding of the University.

The Pennsylvania State University, which in 1953–54 ranked 11th in the Nation in full-time enrollment, is located in the borough of State College, directly in the center of the State. With the Seven

THOMPSON HALL is one of seven units comprising the West Residence Hall area at the Pennsylvania State University. The area was completed in 1950. Members of the American Society for Engineering Education will find accommodations here, as well as in other modern residence halls.

THE PENNSYLVANIA STATE UNIVERSITY and the borough of State College, Pa., are situated in this picturesque setting. Mount Nittany is seen to the left while in the foreground U. S. Highway 322 crosses the campus.

Mountains to the south of the campus and the Bald Eagle range to the north, the University is situated in an area of beautiful mountain scenery.

The main campus includes 236 acres, with a golf course and athletic fields of 153 acres adjoining the main campus to the west, and agricultural experimental plots totalling 3238 acres extending to the north and east.

When the American Society for Engineering Education meets at Penn State in June, Dr. Milton S. Eisenhower will be completing his first five years as president of the University. He assumed the presidency on July 1, 1950 after serving as president of Kansas State College of Agriculture and Applied Science from 1943 until 1950.

ANNUAL MEETING

June 20-24, 1955

Pennsylvania State University
State College, Pa.

Engineering Education in Russia

By M. H. TRYTTEN

Director, Office of Scientific Personnel, National Research Council, and Consultant to the Engineering Manpower Commission of Engineers Joint Council

It is indeed fitting at this time in a meeting called to consider professional matters to give attention to the state of education in the specialized lines of study in Russia.

It has long been a copy book maxim that "knowledge is power." Perhaps we have always held that this is so. But it has remained for the recent years to demonstrate the crushing force of this truth. As mankind has gained more knowledge of nature and its secrets, the power at his disposal by manipulating the secrets of nature has increased by geometrical proportions. That power, like all power, we have learned, can be metamorphosed by simple means from one kind to another, from physical power to technological power, to economic power and finally to political or military power or both, as never before in the history of the world.

It was the United States that demonstrated dramatically the truth of this statement in World War II. Prior to 1941 the United States was the least military of all the great powers. Our military establishment was pitifully small in the years after demobilization immediately following World War I. In the year or two prior to Pearl Harbor, when we were again mobilizing, our ground forces were small, practically without equipment, and we had done very little to bring up to date what we had. We were, in fact, a peace-minded country caught with very little preparedness for war and yet faced with the greatest of all wars.

In the ensuing six years this nation built and equipped the greatest military force in its history and brought to bear a technological power which created and produced in quantity the most devastating military equipment ever known, by a large factor. All of this was done by the use of technology produced and developed for peacetime uses but readily adaptable to military needs. The secret weapon of this phenomenal performance was quite simply a corps of scientists, engineers, management experts, and other specialists whose knowledge was the nation's power in time of need. The nation triumphed because of its highly trained personnel.

It is, of course, not necessarily true that history will again repeat itself in the same way in any future emergency. But there seems little reason to suppose that in any power formula for the future the role and function of highly trained manpower will not again be of the highest importance. The strength of a nation is not measurable by corps, divisions, or battleships in any dominant sense. Its technological power is and will be of the greatest importance. And this is only to say that its corps of specialists, and its means of training more, will be as significant in measuring its power potential as any factor, and more important than almost any other factor.

Local Control of Education

It is particularly appropriate that this subject be one of concern to a great professional society in this country, since we as a nation do not have a central national agency to create educational policy and to provide for its implementation. Educa-

* Presented before the Fall Meeting of The American Society of Mechanical Engineers, September 10, 1954, Hotel Schroeder, Milwaukee, Wisconsin.

tion has been traditionally decentralized to a high degree. It is locally administered and is responsive to local control and local attitudes. Thus it is of the greatest importance that local understanding of the plan of education in the national life and in the national interest be disseminated by groups who are in a position to appreciate it.

This local control of education may have been our greatest strength in the past. It may, however, become our great weakness in the future unless greater awareness of the importance of education is developed at the local level.

It may have been our greatest strength in the past because education in America has always been a response to a peculiar deep seated desire on the part of the American people. Perhaps it was part of the reactions of the immigrants who came to a country limitless in resources and vibrant with high hopes of the future, to think in terms of better educational advantages for their young. Perhaps it was part of the concept of democracy that each individual should have the opportunity to better his station in life and realize his highest potentialities. At any rate, whether it was a private school dependent on free will giving or tax-supported public institutions dependent on the will of the people through their representatives, our schools have fared well and have grown strong.

As a result, probably not consciously anticipated fully in the minds of most people, the nation itself has grown strong. The flow of young people through the professional schools has given to the nation a powerful annual transfusion of trained minds who have found their places in our great industrial and other organizations to help create and develop the technological civilization we enjoy.

However, the boons of the past can not be taken as guarantees of the future. If a locally controlled and locally responsive educational system is to serve national needs in a modern world, local attitudes and local considerations will not be enough. Much has happened to our educational system in the last few decades. The great increase in school enrollments and the consequent concern for the students who do not intend to go on to college has had its effects in focusing attention on the needs of terminal students. Local needs and local influences have been increasingly felt. There is grave concern that in so doing our schools have been increasingly neglectful of those who plan to go further into college and the professions. There is growing concern that fewer of our high school graduates are prepared to go on to the rigorous curricula of the specialized branches. The national interest may have suffered. In a world where power is a matter of greater and greater moment to the United States, the power that resides in our technology and hence in our national resources of trained personnel must be a concern of all who are influential in shaping our educational effort.

The Russian Effort

It is considerations of this kind which make more significant an examination of the Russian effort in technological education. In Russia the role of technology and of technological education as the basis of economic and military power have never failed to be consciously understood. Furthermore, the Russian state has been in a position to implement this point of view from the top down. In contrast to our system where our motivation in the support of education has been the benefit of the individual, there it has been for the state and for the purposes of the state alone.

It is this contrast which stands out in the consideration of the two educational systems. The American tradition is one of deep concern for education because of the opportunities it gives to the individual to realize his own best potentialities. The national needs for the products of the system have been less consciously motivating. Our highly trained personnel has come about almost as a by-product. In Russia the interest has been consciously national and has arisen from the realization that

education and training are necessary to the growth of their power position. The benefits to the individual have been by-products.

In pre-revolutionary days educational opportunities in Russia were indeed limited by comparison with those in other Western countries or with the United States. Before the first World War the United States, with a population about one-third smaller than that of Russia, had a secondary and elementary school enrollment almost twice as large. American universities and colleges had four times as many students as did Russian schools. In 1914 in Russia only about 8 million children attended school, while probably as many as 30 million remained illiterate. In many Asiatic provinces of the Russian empire less than 3% of the population was literate.

Right after the Revolution of 1917 an effort was made to correct this shortcoming, and educational opportunities expanded somewhat, although quite modestly. During the 20's Soviet education was turned into chaos. Under the impact of ideological dogmatic preconceptions and under the influence of extreme ideas of Western liberal educators, Soviet education became highly experimental and an extremely permissive system. Learning by doing was carried to the point of the withering away of schools. The standards of scholarship deteriorated to an unbelievably low level. The expansion of secondary and elementary school enrollment was at a virtual standstill. Training of the professional both in numerical and qualitative terms was at a point of stagnation.

From about 1930 the emergence of an industrial order brought about a drastic change. As the theory of withering away of state, of law, of school began to be revised, we see the restoration of the traditional school, of traditional methods of teaching, with heavy stress on the teaching of mathematics, the natural sciences, physics and chemistry. As complex technology began to emerge under rapid industrialization, as bureaucratic power structures began to emerge and consolidate power in their hands, the leaders began to stress the key role that education of the specialist must play in the development of the communist state. National power, economic power, the power of the state began to be associated with specialized professional know-how, with the regular cadre of specialists.

Great Changes Made

Great changes indeed have been made during the last 25 years. Elementary school has been made compulsory. It is now the Russian boast that seven-year schools are essentially universal, and they expect that by 1960 the ten-year school will be universal. Enrollment in regular higher educational establishments training professionals of various types has grown six-fold. Training of supporting semi-professional personnel increased more than seven-fold. All of this expansion, of course, took place under rational calculations to satisfy the needs of the state and its expanding economy and power. Frequent utterances bear out this fact.

The purpose of higher education is expressed in the Soviet encyclopedia as follows: "To prepare highly qualified politically trained engineering personnel with well rounded education, cultured, wholeheartedly devoted to the motherland and to the course of Lenin-Stalin, capable of completely mastering and using the newest accomplishments of advanced science and technology and of merging scientific theory with the practical work of building a Communist society."

That the emphasis is on the state and its needs is clear. In a recent publication in Russia the remark is made that "The nature of the state determines the aims and purposes of Russian education," and quotes a remark by Stalin that "Education is an instrument whose effect depends on who wields it."

A remark by the eminent physicist, Peter Kapitza, is of particular interest. Speaking in 1943 to the Praesidium of the Russian Academy of Sciences he said in commenting on the central emphasis on

science and technology in Soviet planning: "This is mainly conditioned by the special place allotted to science in our socialist country. Of course, it is well known and generally accepted in other countries, too, that science plays a great part in the development of culture and technology. It has been allotted the leading part in the development of our technology and economic life. Therefore, the organization of science in our country must be more systematic and conscious of its aims than it is in capitalistic countries where it is rather left to chance and has a spontaneous character. In our country the bonds between science and life must be closer and deeper."

Soviet education as an instrument of the state is also strongly supported by the state. About 14% of the annual budget is set aside for so-called cultural-educational expenditures, and although the share of educational expenditures as such is uncertain, the high degree of support is undoubtedly evident.

The Soviet educational system begins with kindergarten into which children enter at three. How universal kindergarten now is can not be determined, but it is believed to be fairly general at least in the major urban and industrial centers. In these schools the elements of reading are taught so that the child should be able to read upon entering the elementary school.

The elementary schools are of seven years duration and concentrate on the three R's with other types of activities in music, art, etc., after hours. Home work is heavy, being specified as increasing from 1½ hours per day in the second grade to 3½ hours in the seventh grade. During the seven-year school a pupil spends about 6.5 thousand hours in class instruction, which lasts each year for 33 weeks with six days of required attendance each week. About 32% of the seven-year curricula is devoted to arithmetic, algebra, geometry, the natural sciences, introductory physics and the elements of chemistry.

After elementary school the student may enter secondary school or a technical school known as a technikum. In the secondary schools, open generally to the better students and largely preparatory for higher education, emphasis is strongly on science and mathematics for all students. There are no electives and about 40% of the curriculum is devoted during the three years to these subjects for all students. These schools are in general large as a result of established policy so as to make it possible to have each subject taught by a competent teacher specializing in a particular field of study.

The secondary school is a matter of considerable concern in Russia. The Party Youth Organizations, the Comsomol, since the early 30's, foster and encourage high scholarship among students. The leader in a Soviet class must usually be a good student—not necessarily a football hero. Indoctrination into the Soviet way of life, of course, permeates this, as well as other levels of education.

Educational Statistics

Perhaps some general statistics may give a concept of the increase in the Russian educational effort during the last two and a half decades. While in 1926 the enrollment in primary and secondary schools was about 10 mililon out of a population of 147 million, or about 7%, in 1950 it was 33 million out of an estimated population of about 193 million, or about 17%. It should be borne in mind that this includes a ten-year education, not twelve, as in America. In the United States, in 1950, the enrollment in the primary and secondary schools was 30,470,000 out of a population of about 152,000,000, or 20%. Soviet upper-grade enrollment (Grades 8–10 of the ten-year school) during the last five years increased fourfold and in 1953–54 was about 4.6 million, which is only about one-third smaller than our four-year high school enrollment. This increase has taken place while our own upper-grade enrollment has been experiencing the results of a low birthrate in the 30's. Graduations this summer

were about 760 thousands, as compared with virtually none in the middle 30's. It should be remembered that these graduates were required to have rigorous preparation in the sciences, while perhaps only 20% of our graduates had general science courses and only 6% to 8% had any physics and chemistry.

In higher education in Russia the enrollment in 1951–52 was 916,000, a 50% increase over the enrollment of 620,000 in 1939–40. In the United States the enrollment was 2,100,000, a 55% increase over the enrollment of 1,364,000 in 1939. However, it must be borne in mind here that a large percentage of American college students are not in training as specialists but are in college for a general education without fixed vocational goals. This is especially true of women.

Those who do not enter the secondary school may enter the technical schools or technikums. These are three or four year schools of a highly practical type intended to train technicians in a variety of subjects, including engineering, agriculture, medicine, law and pedagogy. The products of these schools are what may be called semi-professional and are an important factor in the Soviet economy. These trained semi-professionals represent the core of the Soviet supporting and intermediate level technical personnel, which in America we must supply through our technical institutes, junior colleges, and even through the regular four-year colleges as well. Their training, while short of professional training, is probably beyond that of technical institutes in the United States. The courses are about 40% theoretical, and in engineering include mathematics through the calculus. In engineering alone these schools probably graduate over 50,000 technicians per year. Since a part of their training has been on the job in industry they are prepared to enter at once into the industrial labor force. While technikum students are trained directly for work at the technician level and do not have much prospect of aspiring to higher levels, the door is not closed entirely in that about five per cent are selected because of superior accomplishment and promise for further study at the universities. There were in Russia 3543 technikums in 1952 with enrollments of about 1,000,000 students. Graduates numbered about 350,000 per year. Of these about ⅓ are engineering technicians indicating the figure of about 50,000 used above.

Some idea of the level of work accomplishment expected of the secondary school graduates as a basis for university entrance can be inferred from the entrance examinations. These include besides Russian language, literature and history, up to three languages, mathematics, physics, and chemistry. The mathematics examination includes the usual algebra and geometry, but in addition some complex number theory, theory of equations, progressions, logarithms, and the binomial theorem (trigonometry is included); chemistry includes some organic chemistry.

Very Progmatic Development

Higher education in Russia has had, because of its origin and because of the practical goals of the government, a very pragmatic development. There is little of the American notion of liberal arts education, education for cultural values or education to develop the capacity for valid value judgments. On the contrary, emphasis has been spent on the training of specialists even in the fields of linguistics, social sciences or humanities. The emphasis on science and the practical arts has been heavy.

Higher educational institutions in Russia fall into three classes. There are the traditional universities which to a large extent reflect the European pattern and are even yet strongly influenced by the heritage of Russian scholarship from prerevolution years. These are not many in number. They do, however, supply a large part of the flow of scientists who go into research in all types of laboratories and of the teachers in the secondary

schools and universities, as well as in other types of schools.

Those of the second type are the specialized higher educational establishments which were originated in the late 20's and early 30's by the ministries with technical responsibilities. They have since been placed under the aegis of the ministry of education but retain their special relationship to a particular area of technology represented by the ministry under which they were organized. It is in these institutions that the large majority of the engineers are trained. The curricula in these institutions are built around the industrial field of application rather than around the traditional subject matter divisions. These are communications engineers, mining engineers, agricultural engineers, construction engineers, transportation engineers, etc., rather than electrical, mechanical or civil engineers, as in our system.

Engineering training lasts five to five and a half years, and is based on about 5,000 hours of lectures, classroom and laboratory instruction, attendance at which is mandatory. An engineering student spends about 65% of his time on general sciences and general engineering subjects; about 28% of his time is devoted to narrow specialization and only about 7% to what are called socio-economic studies, which are mostly political indoctrination subjects. The training is supplemented with periods of practical work in industry. This narrow specialization on top of some basic engineering training is responsible for the break-up of traditional divisions.

In 1939 in Russia there were about 750 higher educational establishments which rose to about 900 in 1951–52, a 20% increase. This would not correspond to our 1700 institutions of higher education because of the large number of junior colleges and other types of institutions which would not figure largely in the training of specialists. Probably the number of American institutions in this field with 4-year courses and substantial specialization along professional lines would not greatly differ from the 900—more or less.

In the matter of numbers of graduates, the history of the Russian effort indicates the changing emphasis on numbers and quality. While the number of graduates in all fields in the late 20's was as many as 30,000 per year, the quality of instruction and the solidity of the training left much to be desired. Consequently, in 1930 and the following years, a drastic shakeup in higher educational institutions occurred which tightened standards and resulted in a temporary setback to the expansion of training. At the same time, however, there is evidence of much more attention to the selection of qualified faculties and effective instruction, as well as a rise in numbers graduating until by 1940 over 100,000 graduates, with almost 30,000 engineers, were emerging from training. The war greatly reduced the numbers in training and graduating, although this resulted more from the destruction of institutions by the German invasion than by policies of the government with regard to exemption of students. After the war there was an immediate national effort to rebuild the destroyed higher educational establishments, particularly in the Ukraine. By 1947, 156 of the 162 higher educational establishments in the Ukraine were again functioning. The remaining six were so completely demolished as to require complete replacement. In 1944 only 2200 students graduated from the higher educational establishments of the Ukraine, but by 1946 this number had risen to 15,200, in all fields.

The number of graduates in the sciences is difficult to judge because of the differences in specialization and reporting. In engineering, however, the record is clearer. After the war the numbers of engineering graduates rapidly increased to about 29,000 from all Russian schools in 1948, to 30,000 or more in 1951, to probably about 40,000 in 1953, and to over 50,000 in 1954, according to late indications. This may be compared to about 19,000 from engineering curricula, unaccredited as well as accredited, in American colleges and universities in 1954. It seems probable that the

total number of trained engineers in Russia today is closely comparable to the number in the United States.

In the field of the sciences, advanced work is to a large extent done in the many establishments of the Russian Academy of Sciences which is a major factor in Russian science. There are two advanced levels of recognition neither of which is directly comparable with the American system of degrees. The first of these is that of "Aspirant" or "Kandidat" and is given after approximately three years of study and research. While this level of accomplishment may approximate the doctorate in some fields, in others it may be more nearly the level of the master's degree. It seems probable, however, that in general, and especially in applied sciences and engineering, it should be rated well above the master's degree if not in all cases equivalent to a doctorate. In 1952 there were about 5500 "Kandidat" degrees granted, not substantially different from our own rate of production of doctorates.

The second level of recognition is the degree of doctor of sciences. This degree is granted only after many years of research and substantial recognition by scientific colleagues. In 1951 there were about 531 such degrees granted.

Summary

In summary, it seems possible to conclude that the whole effort in science and technology is a serious one, with full support by the government, which is realistically conscious of the vital role of science and technology in the furtherance of Russian aspirations, be they economic, military or political. There is evidence of substantial accomplishment, to the degree that Russian technology must be taken very seriously.

One further item may be mentioned. Prior to the recent war, military service was obligatory and the duration of individual responsibility was two years. Up to the end of the Stalingrad episode in 1943 students were called into military service. However, in 1943 a law was passed which had the effect of returning many to the universities and retaining students in their courses of training. According to this law, students in about 80 schools of technology were exempted from military service until graduation. Thereafter they were assigned for a period to specified posts in their specialties. As far as can be determined, this law is still in operation.

Thus Russia has apparently solved the vexing problem of the role of the technical specialist in a very direct manner, and in line with its realistic policy of considering scientific and technical personnel as merely another factor, but a most important one, in the total national military potential.

We do not have to make an attempt to abandon our principles of liberal and broad general education, but this should not prevent us from realizing the challenge which we face. Improving the teaching of science at the high school level; expanding the training of scientists and engineers; and the adoption of a consistent policy for the preservation of professional manpower, especially engineering and scientific personnel—all these are measures which are long overdue.

A Community Project in Professional Development[1]

By CORNELIUS WANDMACHER

Chairman, Professional Training Committee, Engineers' Council for Professional Development

The Challenge

One of the greatest challenges facing the engineering profession today is the professional development of young engineers in the first few years after graduation from college.

It is in this critical period that the young man is shaping his goals and establishing a pattern of personal development which will either lead him on to full professional maturity, or will leave him content to serve for years in mediocre, routine technical assignments.

It is in this period that the young man on his own initiative either learns to build upon the foundation established by his educational opportunities or he ceases to grow, falling into a post-college slump and drifting away from the profession for which he has prepared.

This is not a new problem; it has been recognized for many years. But it is a matter of greater concern as the demands increase for higher and higher standards of performance in the engineering profession.

Quantity vs. Quality

That there will always be a shortage of top-flight personnel is a generally accepted fact. At the same time it is pertinent to note that such shortages have qualitative as well as quantitative aspects. In fact, the demands on the side of quality are usually the ones more difficult to meet.

In the words of the National Manpower Council, as stated in its suggested "Policy for Scientific and Professional Manpower":

"Two second-rate engineers are not a substitute for the one first-rate man required."

The problem is not solely to interest a greater number of young men in the profession of engineering, but even to a greater extent to do a more thorough job with those already at hand.

The task of carrying the level of professional competence to new heights can be met in part by adjustments in curriculum and teaching methods, but also in large measure by a concerted effort in post-collegiate development.

Many of the demands made upon educational institutions to prepare the student in various fields of specialization or to round him out in one or another quarter could be met squarely by a sound program of continuing personal growth after graduation.

A Planned Program

The Professional Training Committee of ECPD has formulated such a program which relates to the "First Five Years of Professional Development" and establishes six essential points of endeavor. These are:

1. Orientation and Training in Industry
2. Continued Education

[1] Based on recent experience in the implementation of the 1950 "First Five Years" report of ECPD. Presented at the ASEE Annual Meeting, Urbana, Illinois.

3. Integration into the Community
4. Professional Identification
5. Self Appraisal
6. Selected Reading

Whose Responsibility?

The basic concept under which the six-point program has been established recognizes a responsibility on the part of the profession and also on the part of the individual. These guiding principles have been stated as follows:

a) Industry [2] and the enginering profession must provide the young engineer with a favorable climate in which to grow.

b) The young engineer must realize that the final responsibility for professional advancement rests with him, the individual.

Contributing Factors

Three factors in the life of the community and in the life of the individual affect his personal growth. These are: industry, the engineering societies, and the college or university.

Each makes its distinctive contribution to the development of the young man. Too frequently it is thought that one leaves off where the other begins. Actually, all three must continue to contribute to his growth for many years after graduation. For optimum growth, it is essential that there be close cooperation amongst these three agencies to insure maximum effectiveness.

A Concerted Effort

Engineers are realizing to a greater extent every day that the well-known geometric axiom that "the whole is equal to the sum of its parts," which is applied so frequently in technical matters, is not nearly so restrictive when applied to matters controlled largely by the forces of human relations.

In the area of human affairs, the accomplishments of several groups working closely together on a common problem, with well developed lines of communication, will be of far greater significance than the results of several separate efforts. In other words, the "whole" result of a concerted, cooperative effort can be *greater than* the mere sum of isolated, independent parts.

This is an important principle in two respects. In a community situation it means that there should be close and direct cooperation involving industry, the engineering societies, and the Universities, all working together in any professional development project. For the individual, it means that he should use the opportunities for continued growth offered by all of these three agencies. To neglect any one is to lose the advantage of interrelated stimulation.

Cincinnati—A Pilot Study

For the last two years a pilot-study of the ECPD professional development program has been underway in Cincinnati, Ohio.

The purpose of the pilot operation has been to study how well the six-point program meets the needs of young men in a typical industrial community and what mechanisms of operation are best suited to achieving the objectives of the program.

This study has been carried out through the co-operative effort of a Local Industry Committee, the University of Cincinnati, and the professional development committees of the Engineering Society of Cincinnati with which the local sections of the various participating societies of ECPD are associated.

Community Experience

Experience in Cincinnati has confirmed that "The First Five Years of Professional Development" is a well-conceived program of real merit and of great potential assistance to the young engineer. There are many obvious advantages of a

[2] The term "industry" as used in this report refers to the broad field of professional practice including engineering activities in consulting and civil service, as well as the manufacturing, public utility and construction industries.

well-rounded, package-type of program. A number of suggestions have been made for modification and amplification of the program but the basic framework is clearly sound.

A summary of some of the activities and comments relating to the program may best be made by referring to the six points.

1. Orientation and Training in Industry

Industry's Essential Need

The most important essential of industry is a loyal, efficient, aggressive working organization. Andrew Carnegie once said that if his factories and money were taken from him, but if he were left with his men, he could again rise to his position of leadership in industry.

The most difficult task of management is, as stated in the policies of one of the industries participating in the Cincinnati area project:

"To find the man who has the particular characteristics and experience needed for each place to be filled, and then to take the total number of men so employed and develop them into a trained, unified, efficient and loyal 'team,' satisfied with their opportunities and happy in their relationships with the Company." [3]

What the Young Man Expects

A well-planned orientation and training program will help the young man make the transition to a full-time productive job in industry and at the same time give him the specific knowledge he needs to move forward in the organization which he has selected for his initial employment.

There are two things which young men inevitably expect from an employer: (a) encouragement, (b) recognition. Some companies do much better than others in giving their employees deserved opportunities and proper advancement.

Inadequate personnel development leads to good jobs being filled from the outside rather than by promotion from within the company. Such incidents stifle initiative at lower levels. Good management is self-propagation.

For Companies Large and Small

Small companies need a personnel program as much as large companies, but it must be designed especially to suit their needs at a particular time.

Flexibility in scheduling and a greater air of informality would characterize the program for a small company, to a greater degree. Nevertheless there should be a definite plan and a check-point system for follow-through.

Recent investigations in Cincinnati indicate that most of the larger companies now have a formal orientation and training program. The greatest need for further development of such programs appears in the small and medium-sized companies.

The Cincinnati Industry Committee is currently preparing a check-list type of report which will present a basic framework from which the minimum essentials of a sound program may be chosen by any company.

Individual Initiative

Whether or not there is a definite training program in his company, there is much that the young engineer should do on his own initiative. Being alert and inquisitive; looking over available reports, plans, and literature relating to company activities; learning all he can about other areas of work in his department; with supervisory approval visiting various other sections of a plant or project—all can yield valuable background information and contribute to his self development.

2. Continued Education

To Stop is to Fall Behind

One of the marks of a professional man is his continuing interest in education as a medium of personal growth. The truly professional man recognizes the march of

[3] Armco Policies—adopted originally December 1919.

progress which is constantly occurring and also knows that if he ceases to advance with the group he will in effect be lagging behind. He knows also that the principal purpose of his college education was to establish a firm foundation on which he could continue to build throughout his lifetime.

The most difficult problem facing the young man is to recognize the point at which he must undertake full responsibility for the continuation of his personal growth. During the years on the college campus he has been working steadily in a planned program, a curriculum laid out for him and prescribed by the faculty. Upon graduation he becomes his own educational director.

The Importance of a Goal

During the years in college the student engineer has been working toward a well-defined, specific objective, his degree. After graduation he may seek an advanced degree, or he may simply seek to deepen or to broaden his education in certain fields as may best pertain to the line of endeavor which he chooses for his life's work.

In either case, the young engineer must learn that education is a journey—not a destination. He must come to know how important a carefully planned educational program can be in keeping him mentally alert and in providing the stimulus for continuing personal growth. He must establish his own professional objective and work each year steadily toward that goal.

Experience has demonstrated that unless the young engineer formulates such a plan soon after he leaves college, he is not likely ever to do so. The core of his plan should be to relate the basic principles of science and of the humanities to his experience in technical matters and to his associations with people.

Growth in Part-Time Graduate Study

While it is not the intent to convey the impression that part-time graduate study is the most important aspect of the "Continued Education" program, it is a point on which a great deal of definite progress has been made in the last five years.

A survey in 1948–49 which inquired into the opportunities available in 50 of the principal industrial communities of the country indicated that none existed in over 70% of the areas investigated.

A similar survey now being completed indicates that only about 20% of the major industrial areas of the country are now without any opportunities for part-time graduate study on the part of the young practising engineer.

Results of a Concerted Effort

The program established only last year at the University of Cincinnati was sponsored in the main by a group of industries which had been brought together by the stimulus of the ECPD Community Project. While the plan had been under consideration by the University for some time, it was the concerted effort of the Local Industry Committee, the engineering societies and the University which brought it to a state of reality, with an enrollment of nearly 300 students in its first year.

In this instance, ten industries supported the publishing of a special announcement of the graduate engineering program and actually promoted the program in their own organizations through top management channels.

A Need for Short Courses and Seminars

In addition to the demand for credit courses at the graduate level there is also an ever increasing need for short courses and seminars of the non-credit type. These mediums represent probably the best way to introduce the young engineer to advanced topics in his specialized field and to help him keep abreast of new developments in engineering practice.

Such short courses may be sponsored on a company or industry-wide basis, by engineering society groups, or by special sessions on the University campus.

A Broad Gauge Program

Some of the more broadening outlets for continued education are found in lecture series and forums.

One of the more successful projects of this type in Cincinnati is the Business and Professional Men's Lecture Series, which presents outstanding speakers in the fields of economics, government, literature, world events, journalism, and sports. Nearly 20% of the registrants in this program during the past several years have been engineers.

3. Integration into the Community

A planned activity for introducing the young engineer into the community in which he begins his career and professional practice divides itself into two parts:

a) Aiding the young man in developing a sense of belonging in his new environment, and
b) Pointing out to him the civic and professional responsibilities which he should assume.

Developing a Sense of Belonging

Each newcomer wants to feel a sense of participation in the group activities of which he becomes a part. Young people are eager to participate in community affairs and yet are extremely hesitant to introduce themselves into the life of a community which seems sufficient and complete without them. Community groups must, therefore, feel a responsibility to make the initial contacts with new young people.

The professional activities committee of ESC each year arranges a Newcomer's Night for welcoming all men who have recently arrived in the community. Names of newcomers are furnished by the industries. The letter of invitation to attend this special program includes data on activities of all 24 participating societies of the Technical and Scientific Societies Council of Cincinnati.

Newcomers' Guide

During the past year an ESC committee has been preparing a community orientation booklet for new engineers arriving in the Cincinnati area. The six chapters include:

1. Professional Activities
2. Educational Opportunities
3. Civic Information
4. Cultural Activities
5. Recreational Facilities
6. Religious Activities

It is planned to distribute such a booklet to newcomers this year through the cooperation of industry.

Civic Participation

The community has a definite interest in drawing professional people into its activities. Engineers, particularly, can contribute not only sound judgment for the solution of civic problems but special knowledge applicable to city planning, construction and public services.

Engineers are frequently critical of the shortcomings of solutions to community problems; but not always have these same engineers done anything about these problems themselves. The additional education and training, beyond the average, which engineering graduates have enjoyed places upon them an obligation to use the benefits of such education in the public interest.

As long as any engineer limits his attention to his job alone, he will remain a technician. Only as he develops an interest in servicing society through his community as well as through his job will he begin to discharge the responsibilities of the professional man he seeks to become.

The ESC Committee on Public Affairs has in the past year been active in and kept the membership informed on matters relating to expressways and turnpikes, fluoridation of the city water supply, and choice of a new City Manager. An active member of ASCE was recently appointed to the post.

Public Affairs Manual

An excellent reference on this topic, which has recently been brought to the attention of the committee, is the ASME Manual, MS–61, "Citizenship and Participation in Public Affairs" which includes the Engineers Manifesto on Civic Responsibilities, prepared by Herbert Hoover, and reprints of the Roy V. Wright Lectures.

4. Professional Identification

In the original statement of the six point program, this section was headed "Professional Registration."

Discussion in Cincinnati and elsewhere indicates that this point probably should be established on a broader basis. This new approach recognizes the importance to the young engineer of taking "two steps" at graduation.

Two Steps

Two items of equal importance are essential to being identified as a professional man:

1. To become actively associated with an engineering group such as a national or local society.
2. To qualify for professional registration.

Society Membership

The several plans for "graduation" from student chapter membership to regular society membership have generally worked well in the first year after college but some societies report a large drop in young men after the first year.

Most engineering societies do recognize how necessary it is to provide an adequate program at the local level for young engineers. Few young men have an opportunity to attend national meetings. The only personal contact which they have with their societies, therefore, is through the local section program. More and more such local programs are being directed toward the young men only a few years out of college.

Getting Acquainted

Moreover, young men usually expect senior members of the societies to make the first overtures in striking up an acquaintanceship. This fact should be taken into account in planning any program to stimulate participation of young engineers.

Along these lines the Cincinnati section of AIEE has successfully conducted an annual "Father and Son" dinner, in order to better establish personal acquaintances between the young recruits and the senior members of the section.

Professional Registration

The work of encouraging professional registration of the graduate engineer is now well in hand. In some states approximately 75% of the graduating students currently take engineer-in-training examinations.

This EIT movement which stimulates the senior-year student to take the examinations immediately upon or before graduation regardless of where he intends to practice, has been greatly advanced by two factors:

a. The excellent opportunities which exist for the transfer of this credit by reciprocity in other states.

b. The general policy which permits the use of EIT examination credit toward the written examination requirements for full licensing.

While advancement in his career is entirely dependent upon the young engineer's technical and other abilities and how he applies them in his work, these two steps of professional identification contribute much to his self-development and professional stature.

5. Self Appraisal

Success depends in a large measure on working in a field for which one is well suited by virtue of education, aptitudes, and interests. The better the young engineer understands the requirements of the different types of work and the better he understands himself the easier it is

for him to relate his objectives to his abilities.

It is impossible to overemphasize the fact that technical competence is the *necessary* but not the *sufficient* condition for becoming a professional engineer. There must be developed, in addition, certain qualities of personality and of character which will establish unmistakably a feeling of trust, confidence, and loyalty in man-to-man relationships.

6. Selected Reading

On this point much assistance to organized engineering groups desiring to stimulate good reading will be forthcoming from the various public library systems which are currently faced with the competition of other recreational media. Engineers in most communities could well afford to become better acquainted with the diverse library facilities available to them.

The Cincinnati and Hamilton County Library has furnished the ESC headquarters with a loan collection of 80 books from the Reading List for Engineers. Synopses of these books have been written by the library committee and published serially in the *Engineer and Scientist*, a weekly bulletin which is circulated to all Society members in the city.

A Threefold Reading Program

Discussions of reading habits have brought out the fact that any reading program should include three essential parts:

a. General readings in biography, travel, history, economics, sociology, psychology, philosophy, natural science and literature, including fiction and essays.

b. Technical readings as represented by books listed in the various sections of the ECPD Selected Bibliography of Engineering Subjects.

c. Professional reading such as that made available by the periodicals of the National Societies and industry.

Reading List for Engineers

Some 300 junior engineers are cooperating in a review of the ECPD Reading List for Engineers, to ascertain the adequacy of the current edition. A revision of the list based on the evaluation by these young men will be considered during the next year.

Several sections of the Selected Bibliography of Engineering Subjects are currently being revised.

Implementation

As now conceived the plans for implementation of the "First Five Years" program require simultaneous promotion along three lines:

1) Providing an introduction to the program for students before graduation,
2) Stimulation of a better understanding of the program in the respective national committee of the participating societies of ECPD,
3) Development of a number of community projects with the aid of industry in selected industrial areas.

Before Graduation

During the past year the Training Committee has taken a number of definite steps toward the introduction of the "First Five Years" program to senior engineering students before graduation from college.

It is now generally recognized that the avoidance of the "post-college slump" is not entirely a post-college task. The ideal time to begin to talk with young engineers about a program for professional development after graduation is while they are still members of a more or less homogeneous group on the college campus.

Use of "First Five Years" Brochure

Thirteen colleges having professional development programs for seniors participated this year in a trial use and distribution of the "First Five Years" brochure. Schools emphasizing the ECPD six-point professional training program in cooperation with the committee this year included:

Alfred University
University of Akron
Carnegie Institute of Technology
Case Institute of Technology
University of Cincinnati
University of Detroit
Fenn College
University of Nebraska
Newark College of Engineering
Ohio Northern University
Ohio University
University of Tennessee
Wayne University

While many colleges have professional development programs of various patterns, some of them running from freshman through senior years, the objective of this committee is to introduce the graduating student to a well-rounded, unified program such as the six-point program. Indications are that this may best be done in the final semester, just prior to graduation.

Revision of the "Professional Guide"

As the six-point program for the "First Five Years" becomes more fully crystallized, it appears desirable to have a statement of this program as an appendix in the "Professional Guide for Junior Engineers."

The current supply of the "Guide" is now almost exhausted. In a number of years of usage of this manual, only a few suggestions for revision have been received, some of which will be incorporated in a new printing. It is the opinion of the ECPD committee that the original chapters by the late Dr. William E. Wickenden should be preserved in the "Guide" but that steps should be taken to incorporate the statement of the "First Five Years" program at the earliest possible date.

Copies of the "Professional Guide for Junior Engineers" are widely used by colleges and universities and are regularly circulated to all young members of EIC and AIME.

Young Engineering Teachers

ECPD has a special stake in the Young Enginering Teachers of ASEE. This group is composed predominantly of men who are currently interested in their own personal professional development. At the same time they represent one of the greatest potential sources of inspiration to students in the "before-graduation" aspect of the "First Five Years" program.

Many of the YET groups this year gave attention to the discussion of the six-point program and a vigorous promotion of professional guidance programs has been declared one of the main objectives of the committee.

Promotional Aids

For the assistance of groups interested in the development of local projects the Training Committee has prepared two brochures, a set of display posters, a 35 mm slide series, and condensations of the various sections of the 1950 report suitable for serial publication in society magazines and bulletins.

Conclusion

It is the conclusion of this study that many of the demands now made upon educational institutions to prepare the student in various fields of specialization, or to round him out in one or another quarter, will be met in the future by expanding programs for continuing personal growth after graduation.

In these programs, for which the six-point plan of the "First Five Years" provides an excellent base, industry and the engineering societies will take an increasing responsibility in co-operation with the colleges and universities of the community in which the young engineer begins his professional practice.

At the same time it is expected that further steps will be taken to introduce the "First Five Years" program to students on the campuses of engineering colleges "before graduation."

The Role of Physics in Engineering Education*

By N. H. FRANK

Head, Department of Physics, Massachusetts Institute of Technology

The problem of reassessing the role of physics in engineering education has come to be a matter of considerable urgency and significance primarily because of the rapidly changing character and expanding scope of both engineering and physics. This assessment must be made not only in the light of these facts, but also in terms of the requirement of establishing objectives such that, as far as one can forsee, the continuing evolution of both physics and engineering will not render them prematurely obsolete. In general, both physics and engineering are confronted with the same fundamental problem, viz., that of inculcating into the student a more difficult expanding body of knowledge, with an increasingly subtle and complex theoretical base, and essentially no more time available in which to teach it. Any projected plan of coping successfully with this challenging problem must be viewed in the light of the changing pattern of requirements in both engineering and physics education. Let me start then by discussing briefly the salient points in these areas.

The Changing Pattern of Engineering Educational Requirements

Of utmost significance to our considerations is the relatively recent shift of the technical base of engineering from one that is largely empirical to one which is preponderantly scientific. This change clearly throws the spotlight on the basic sciences, especially on physics, and depicts them as playing a critical role in engineering education. There has also come into being a greatly augumented need for a deep and fundamental insight into a multiplicity of disciplines over and above the more traditional engineering subjects, such as the humanities, social sciences, management, physical sciences, etc., and also of providing opportunity to the student for gaining experience in synthesizing broad solutions to complex operational problems. There is a rapidly growing emphasis on the integrated character of engineering problems—as examples, I might cite the broad areas of transportation and of the conversion and distribution of power.

Not only are the number of pertinent disciplines growing, but the requirements for depth of comprehension are sharply enhanced, and this is particularly true with respect to physics. The need for more modern physics, exemplified by solid state and nuclear physics, is well attested to by the recent recommendations and programs drawn up by committees of this society. The pressure for skillful and effective inclusion of these subjects into engineering curricula is real and great, and stems in no small measure from the unprecented speed with which discoveries in pure science are translated into practical application.

May I suggest that because of the foregoing there is urgent need for far-reaching changes in the character of engineering science subjects. Much of the purely factual information and many of the items relating to current practice traditionally included in such subjects should be eradicated to make room for more urgent needs.

* This article is the text of an address given by the author at the annual meeting of the American Society for Engineering Education at Urbana, Illinois, June 15, 1954.

The Changing Pattern of Physics Educational Requirements

Not only have the requirements of engineering education changed markedly, but the same is true to at least as great an extent in physics education itself. Twentieth century physics has provided us with probably as much progress in the understanding of natural phenomena as had been attained in the whole previous history of mankind. The significance of this progress is by no means confined to the simple gathering of large amounts of new factual matter, but there has come into being an abstract and complex modern theoretical physics—I refer to quantum theory and relativity—which are no longer pure intellectual pastimes for the few, but are essential for modern engineering as well as for physics. The increase both in the complexity and scope of physics calls for the excision of much of the traditional subject matter of physics courses and for the introduction of the modern spirit and the inclusion of examples from modern physics to illustrate fundamental principles at *all* levels of instruction. This is by no means an easy task, especially for those of us who have been brought up in the tradition of the older physics. We are loath to keep from the students many of the classical applications which have served us so well in the past and which are as valid and useful today as they ever were. But a choice must be made, and I believe that we must look upon this sacrifice as a necessary one, analogous to foregoing a luxury, no matter how pleasant, in the face of more urgent needs.

With this brief resume of the more pertinent present day educational requirements in physics and engineering as a background, I now turn to the task of attempting to formulate the objectives of physics in engineering education. As a consequence of my earlier remarks, it seems evident that physics must play a dual role in engineering education. First, physics plays the role of one of the great humanities, and as such it follows that physics should be taught as a pure science. I feel that physics, along with mathematics, represents one of the greatest intellectual achievements of mankind, and the impact of the growth of science on social and political ideas has been such that a proper understanding of our present day culture and problems is difficult to attain without an adequate scientific background. This role of physics as a humanity fits in admirably with the growing emphasis on humanities in all engineering curricula.

Secondly, there is the more traditional role of physics as a technical base for engineering science subjects. In the past this has been almost exclusively the reason for the existence of physics in engineering curricula and as such the teaching of physics more often than not assumed the form of introductory engineering. I need hardly remind you that such limited objectives for physics are no longer adequate. Keeping in mind this duality of purpose of physics for engineers, I should like to propose the following tentative statement as encompassing the broad objective of physics in engineering curriculum: THE OBJECTIVES OF PHYSICS COURSES IN ENGINEERING CURRICULA ARE FIRST, TO GIVE THE STUDENT A BROAD AND COMPREHENSIVE BACKGROUND IN PHYSICS AS A CULTURAL SUBJECT, AND SECONDLY, TO SUPPLY A DEEP QUANTITATIVE SCIENTIFIC BASE ON WHICH A MAN MAY BUILD HIS ENGINEERING CAREER WITHOUT SIGNIFICANT LIMITATIONS OF FLEXIBILITY OR DEPTH OF PENETRATION IN A GIVEN AREA.

If this is a sound statement, then it becomes clear that there must be great emphasis on *pure* physics in the physics course for engineers. Applied physics should be taught largely by engineers as an integral part of engineering science subjects. At this point I feel it necessary to refer briefly to proposals which have been made which would take over by engineers the teaching of all classical physics and delegate to physics departments the

limited task of teaching modern physics. To my way of thinking—and I am sure that physicists as a whole will agree—any such course of action would not only be bad but practically fatal. Physics is a tightly integrated and coherent subject in spite of its wide ramifications and cannot be dismembered into classical and modern physics without destroying the very benefits which one aims to derive from physics education. Modern physics and its principles have evolved as generalizations from classical physics, and it is virtually impossible to impart a solid quantitative understanding of modern physics without a sound classical base as taught by physicists.

Cooperative Planning by Engineers and Physicists Needed

I submit that there is a firm requirement for active cooperative planning by engineers and physicists to create mutually supporting subjects with well defined objectives. Let me illustrate briefly with a few examples of the sort of changes which might well be made as a result of such an effort. In mechanics the physicist should have as his primary objective the teaching of the basic laws, with great emphasis on the broad conservation principles (momentum, angular momentum, energy). The latter, rather than Newton's laws themselves, have provided the springboard for the evolution of quantum theory and relativity. An introduction to as much of modern physics as relates to mechanics should also be undertaken and the examples used to illustrate the principles should be drawn to a large extent from present day physics. I see no reason, for example, why electric and magnetic forces should not be introduced in the beginning mechanics course, even though traditionally they have been excluded. The engineering mechanics should then take over in its entirety the subject of statics, essentially all of the study of constrained motion, and much of fluid dynamics, acoustics, and similar topics. In electromagnetism the physicist should be concerned with the exposition of field theory and microscopic electrodynamics, whereas the engineer should teach circuit theory and large-scale, macroscopic electrodynamic theory. In thermodynamics I would suggest that the physics course be concerned primarily with kinetic theory and the statistical approach to the subject, whereas engineering thermodynamics could dwell on the applications and exposition of classical thermodynamic theory. I could go on at length with further examples, but I hope this will suffice to illustrate the sort of changes which I envisage. I cannot resist the temptation at this point of making a few remarks about the long-standing controversy with regard to the systems of units employed in engineering and in physics. I myself cannot get excited about these matters, since I believe a student can learn more than one system, but it seems to me that the differences of opinion that have existed in the past will gradually disappear, since the introduction of modern physics into engineering will call for a revision of engineering units to conform more to those employed in physics. For example, I have long been amused by the controversies about mass and weight and the insistence of some engineers on talking at length about local and standard values of the acceleration of gravity. The concept of mass as used in present day physics is a far cry from the primitive notion of quantity of matter. I refer to the concept of mass in the theory of relativity, or to the effective mass of an electron in a solid. These concepts are hardly dependent on the gravitational field of the earth, so perhaps we have finally reached a point where this controversy will disappear.

Now, all that I have been proposing would be of little import if it were not supplemented by an additional and crucial requirement relating to the intellectual level of the courses which are involved. There is a stringent requirement for a quantitative, intellectually challenging treatment of physics, and there can be no

place for so-called survey courses at any level of instruction. The abstractness and the indirect methods of attack which characterize modern physics must be faced squarely, and not circumvented. Turning our backs to the difficulties which arise from these factors will in no way help solve the problems which confront us. This intellectual requirement is a "*must*," independent of the student body. I realize that in many schools the relative limitations of background of engineering students will create major difficulties, but, as I have already said, nothing can be gained by avoiding the challenge.

In talking about the quantitative treatment of physics, I should point out that there is always a risk that physics and engineering science might turn into applied mathematics because of our enthusiasm for advanced quantitative methods. This, of course, is to be avoided. There is an urgent need for developing interest and skill on the part of the students in the methods of probing into new areas in which our understanding is either lacking or incomplete. Here much is to be learned from the history of physics. We must concern ourselves with the development of intuition and judgment; for the feeling for orders of magnitude of physical quantities; and for the pertinent as contrasted with irrelevant or minor factors in complex problems. In charting a course which gives proper relative emphasis to rigid mathematical analysis on the one hand and to intuitive, qualitative thinking on the other, we face a truly difficult problem which can only be solved satisfactorily by the very scientific methods which we try to impart. There will be many satisfactory solutions to this problem, I am sure, and there will be variations depending on students, on subject matter, and not least of all on teachers. This problem constitutes the greatest single educational challenge for the future and requires for its solution great emphasis on laboratory instruction and proper attention to the experimental foundations of science.

Conclusion

In conclusion, may I plead not only for receptivity on the part of engineers to a new approach to our educational problem, but for an urgent and compelling demand by them for such a new approach. To implement successfully any significant changes, I must mention the role that textbooks play. In the last analysis, the only really effective means of communication of new ideas and patterns of education are provided by the textbooks used by the teachers throughout the country. I am sure that our friends in the publishing business stand ready to do all they can to help bring into being suitable textbooks of a new character which will help us in our endeavors. Of course, we must remember that the publishers have their problems too, and we certainly cannot except them to publish large numbers of books for which there is a negligible market.

Essential to the success of any effort in this domain is cooperative planning by both engineers and physicists, encompassing far reaching changes in our current educational pattern. This planning should aim at establishing a broad framework and broad objectives; the details and choice of paths leading to these goals must be left to individual schools and their faculties.

This, then, is my assessment of the real challenge to be met if engineering education is to meet adequately the requirements of our modern world and to foresee intelligently the expanding horizons of the future. In helping attain these ends, physics can and should play a most important role.

Employers, Ethics and Novice Engineers*

By CLEMENT J. FREUND

Dean, College of Engineering, University of Detroit

A dean of engineering earns his living by doing a number of things. One of these things is to listen patiently and sympathetically whenever an alumnus, especially a recent graduate, feels like weeping on his shoulder.

Not long ago such a one was in my office to tell me his troubles. His troubles were really not very serious. He was two years out of college. He had a good job in one of our Detroit automobile manufacturing corporations. As I remember it, he had something to do with the development and redesign of the combustion area above the pistons. He was making good progress as far as I could see. But he was restless and dissatisfied, and he thought that he ought to resign and look somewhere else.

This interview was a familiar experience. It seems that very many of our engineering graduates are unhappy and discontented.

A Comparison

I could not help comparing this recent graduate with a young physician of my acquaintance who is an interne in a hospital near my home.

The young physician studied eight years following high school; the young engineer four years.

The physician spent about $10,000 in tuition and fees—or his parents did; the engineer about $2500.

The physician has impossible working hours. He is on call day and night; the engineer works an easy forty hours per week.

The physician is married but lives at the hospital. He gets his meals there although he has an occasional day off. The engineer lives pleasantly with his wife and small son in a five room apartment.

The physician is paid $1200 per year, and his keep; the engineer was paid $4600 per year when he graduated, and he gets more than that now. The physician is contented with his rugged and meager assignment; the engineer is sitting on top of the world and is dissatisfied.

Obviously, the young interne has something which the engineer does not have. The engineer has an immense advantage over the interne in every respect except for that something. That something makes the young interne happy with his lot, while the engineer is clearly unhappy.

I know both young men very well. I have studied the attitudes and mode of life of each. I have just about made up my mind that I know the secret of the interne's peace of soul.

Professional Standing

The interne is a member of a great profession; he is proud of it and happy about it. The engineer may belong to a profession some day but he is not sure. Certainly he does not think much either of his profession or about it.

The interne is respected. He enjoys all the strictly professional privileges of the oldest surgeon on the staff. He has the title of doctor, and all in the hospital address him as doctor. He has authority

* Presented at the Relations with Industry Division, American Society for Engineering Education, University of Illinois, June 15, 1954.

over nurses, attendants and other employees, many of them twice his age.

Nobody in the hospital may openly question his medical judgment except senior physicians and surgeons. Patients do not know the difference between him and the younger men on the regular medical staff.

The engineer, on the other hand, is just another employee, no different from thousands of toolmakers, assembly men, payroll clerks, draftsmen and the like. He has authority over nobody. He is a college trained engineer but, except for personnel officials, nobody knows it and nobody cares.

Significance of Ethics

What has all this to do with engineering ethics? A great deal, it seems to me. Let me start this way. Many employers are worried about the Engineers and Scientists of America. This is the union, as most of you know, which is currently attempting to enroll employed engineers. Other unions have tried, and none have achieved more than an ambitious start. But the succession of failures is small consolation to nervous engineering employers; this union might succeed.

This brings us to the core of the whole argument. In my view, employers will have no union trouble if they recognize the professional character of their engineers.

Employers, of course, do recognize technical ability and competence in engineering. But technical ability and competence are not the sum total of professional standing. Professional standing is made up of two elements: technical competence and training, and high honor and integrity, or ethics.

Engineering employers, it seems to me, ought to be as much concerned about the ethical standards of engineers as they are concerned about technical education and ability.

When I say ethical standards, I mean the ethical codes of the engineering profession. I do not mean the special policies and regulations of the particular corporation in which the engineer is employed. I make this point because employers occasionally call an employee unethical merely because he has violated some regulation of the individual employer which pertains only to his business.

It would be interesting to gather here at Urbana all the seniors of the University of Illinois who were interviewed by employers this year. I suppose there are hundreds of such students. It would be interesting to inquire of this crowd of seniors if a single one of them was asked by any interviewer what he knows about the ECPD code of engineering ethics; or about the code of the American Society of Mechanical Engineers, the American Society of Civil Engineers, etc. Not a single hand would be raised in answer to your question.

When engineering employers habitually and regularly insist that engineers shall know their ethics, just as they insist that engineers shall be technically competent, they will have gone a long way toward giving engineers professional standing. Then, and not until then, will engineers enjoy the professional standing of physicians and lawyers in the employ of corporations.

Once the employer has given his engineers full professional standing, he can safely discard the countless rules and regulations of the familiar employees' handbook, as far as his engineers are concerned. If he explains to his engineers a few basic policies of his corporation, he can thereafter safely depend upon their honor and integrity as professional engineers.

Solution

The employer who does all this need not worry about the Engineers and Scientists of America, nor about any other engineering union. If he will give to engineers the personal privileges that go with professional status, he will have no

union problem in his engineering staff, and few personnel problems of any kind.

Unions do not try to organize clearly professional people when they are known to be professional. Did you ever hear of the AFL or the CIO trying to organize the physicians of the Mayo Clinic at Rochester? Did you ever hear of an AFL or CIO union competing in Chicago with the Cook County Bar Association? Did you ever hear of the American Federation of Methodist Ministers? Did you ever hear of some radical Italian union trying to organize the staff of cardinals and monsignori at the Vatican?

No Misunderstanding

It is very easy for me to be misunderstood about an issue like this. It may be important for me to explain at this point, and to explain emphatically, that I am not opposed to labor unions in their proper function, and when they are decently and legally managed. But I am positively opposed to labor unions in medicine, in law, in the ministry and in professional engineering.

Conclusion

We engineering educators must face up to our responsibilities. There are two sides to this question of engineering ethics. If General Electric, the Bell Telephone System, Westinghouse, Allis-Chalmers, and all other engineering employers begin to look for young engineers who know their ethics, it is going to be up to us in the colleges to teach ethics.

In the past, we have taught them to be reasonably competent in technology; but we have told them precious little about engineering ethics.

I respectfully suggest that it is high time for us to mend our ways.

College Notes

Top national authorities in education and professional fields will participate in a series of 10 academic symposia scheduled during the Centennial Year of **Michigan State College** in 1955. The Centennial year will open officially Feb. 12 with Founders' Day featuring an address by James B. Conant, former president of Harvard University and now U. S. High Commissioner of Germany. Other highlight programs will be an October Convocation at which President Eisenhower is expected to speak, and a world's fair Centennial of Farm Mechanization in August featuring a century of farm equipment. The academic symposia will cover the fields of education, business, agriculture, home economics, engineering, science, the arts, communications and veterinary medicine.

Comments on Interim Report of Committee on Evaluation of Engineering Education

Industry Views the Interim Report

In cooperation with the ASEE Committee on Evaluation of Engineering Education, the General Electric Company has submitted the Interim Report to a number of leading industrial executives for their comments. The following is a summary of these comments. We received approximately 100 replies, about 60 from within G.E. and 40 from electric utility executives. There is almost unanimous agreement that the principles embodied in the Report represent a marked advance in engineering education.

The specific comments, which largely emphasize portions of the Report, are grouped into five broad areas and arranged approximately in the order of number of times mentioned.

A. General

1. The greatest shortcomings of the young engineer are inability to express himself and a deficiency in human relations understanding.

2. Corporations are in a better position than the colleges to teach engineering practice. One reason for this is that engineering methods change so rapidly that a specific technique taught in the schools is likely to be obsolete by the time the student is ready to put it into practice.

3. An engineering graduate should be educated, not merely trained. Since upon completion of his undergraduate training an engineer is merely beginning to learn, colleges should concentrate on providing the engineer with a broad base. This means, a fundamental understanding of basic sciences and a humanities training that is closely coupled with his engineering training.

4. Some writers feel that more should be done to develop the latent creative abilities of the students.

B. College Educational Methods

1. The similarity and analogies of the concepts of the basic engineering fields should be emphasized.

2. Greater differentiation should be made on the basis of ability and more opportunity should be provided for the gifted student to perform to the limit of his abilities. Here we are interested in the segment of the class which is capable of accelerated study.

3. More attention should be paid to reading and study habits. The student who is taught to read rapidly and comprehensively can double his productivity.

4. The methods of attack utilized in solving overall engineering problems should be emphasized.

5. Closer collaboration is needed between the Physics, Engineering, and Mathematics Departments. The studies of Mathematics and Engineering should be well coordinated so that the student studying Engineering can make full use of all the mathematical tools available.

6. Although engineering laboratory time can be reduced, we should be careful not to eliminate laboratories teaching basic experimental methods. Laboratories can be used as problem solving experiences and they permit practical application of the theories.

7. With the introduction of these proposed curriculum changes, motivation of

the student may become a problem since the student will receive less actual engineering education early in his college training.

8. Periodic rating of professors is desirable since a proper balance of technical competence as well as teaching ability appears to be necessary for effective teaching.

9. The cooperative system for training technical people offers great advantages to both the student and industry.

C. College Curriculum

1. The greatest controversy in this area centered on the four versus five year curriculum. A slight majority favored the four year program, feeling that further college training was not always necessary and that widespread adoption of the five year course would reduce the number of graduates available.

2. The student should be taught effective presentation, both oral and written. Inability to express himself is felt to be one of the most severe shortcomings of the engineering graduate. In this connection, an attempt should be made to integrate the study of English composition with technical report writing.

D. Changes in Pre-College Training

The following changes are recommended in order to provide the colleges with better qualified high school graduates and to insure that the right people enter the engineering profession.

1. More emphasis should be placed on counseling and guidance in the high schools. Aptitude and interest tests should be taken by all students and they should receive vocational counseling from qualified individuals.

2. Early attention should be paid to study and reading habits. A course in comprehensive reading should be made available to high school students as an elective subject.

3. In the high schools as in the colleges more opportunity should be presented for the interested student to perform to the limit of his ability. Most of our high school education is directed toward the middle or lower portion of the class thus discouraging the initiative and wasting the time of the more capable students.

PAUL J. HESS
Engineering Services Division
General Electric Company

Comments on Evaluation Report

Dr. Lynton E. Grinter, Dean
Department of Engineering
University of Florida
Gainesville, Florida

Dear Dr. Grinter:

Under date of August 2, 1954, Mr. Clarence H. Linder, Vice President of the General Electric Company, forwarded a copy of the "Interim Report of the Committee on Evaluation of Engineering Education" to Mr. H. J. Cadwell, President of the Western Massachusetts Electric Company. In the letter of transmittal which accompanied the report Mr. Linder suggested that the committee would probably welcome comments on this report and that said comments should be addressed to you. Mr. Cadwell has referred Mr. Linder's letter and the report to me for study and comments.

I wish to congratulate the committee on the completion of a very excellent report. It is evident that a great deal of work has been done on this general question and I think that the report represents a very definite contribution to the solution of a difficult problem.

We are in full agreement with the objectives of engineering education as outlined in the report. We approve the placing of emphasis in undergraduate work upon fundamentals of mathematics and the engineering sciences. Emphasiz-

ing these particular features will go far toward realization of the first objectives of engineering education; that of providing an adequate technical foundation. We have felt for some time that the engineering school graduate was not, in a large percentage of cases, a really well educated individual. Quite frequently he lacks proper perspective and is inclined to place undue weight on some special feature of a problem. Many of these individuals lack ability to communicate their ideas and their understanding of what are generally known as the humanities leaves considerable to be desired. The objective as set forth in the report of developing the individual along these lines meets with our full approval.

Mr. Linder has suggested that we use this question "Are we convinced that the recommendations of the report will, if put into effect, produce the broadly trained, versatile young men the industry must have as recruits?"

As a broad general answer to such a question, I would say that we are not convinced that putting these recommendations into effect will produce such men. However, I would modify this general statement by saying that it is our opinion that the following of these recommendations will constitute a definite step in the direction of the desired objective. It is our opinion that additional work must be done before we can realize the goal mentioned above. Further studies should involve both educators and representatives of industry.

The Foreword of the report emphasizes the fact that very little space is given to an analysis and evaluation of graduate study in engineering. However, some reference is made to graduate study and certain questions regarding it are raised.

On page 18 of the report the following statement appears:

"5. The demand of industry for engineers with more than baccalaureate education has resulted in extensive part-time programs at the graduate level for industrial employees."

Following this statement a number of questions are raised. The first of these is: "Do such programs meet high graduate standards?" Does this question refer to academic standards or to standards set by industry? If academic standards are implied, we might counter this question with one somewhat as follows: Is it necessary that they should meet so-called high graduate standards? Is it not possible that such courses might be given for the express purpose of improving the knowledge and usefulness of individuals in a particular field? It seems to me that before we can answer such questions it is necessary that we be sure of the objectives of such a course of study. Under this same number a question is raised regarding the sufficiency of part-time study. I think considerable care should be used in answering this question. In the past a great many individuals have been forced to rely on part-time study to obtain important parts of their technical and other education. It is undoubtedly true that this condition will continue in the future. It seems to us therefore that one of the problems in connection with engineering education is to see that part-time study of such character as to provide degree programs comparable with those involving full time resident study are available to those who require such education.

To summarize, it is our opinion that the function of engineering education is to provide a well educated individual properly grounded in both technical and general educational fields who is in a position to continue his education after leaving college. We should bear in mind that the purpose of engineering education is to prepare individuals to implement and lead in the development of a continuously growing and expanding economy.

Very truly yours,
WESTERN MASSACHUSETTS
ELECTRIC COMPANY

Signed: J. W. Bennett,
Chief Engineer

Southern California Edison Company, Ltd.
Edison Building
Los Angeles 53, California
October 8, 1954
Mr. J. F. Davenport
Vice President and General Manager

A short time ago you sent me a letter that you had received from Mr. Clarence H. Linder, Vice President, General Electric Company. At that time you requested that I study the Interim Report of the Committee on Evaluation of Engineering Education that came with Mr. Linder's letter and offer any ideas concerning it. I asked Mr. R. H. Adams to help with this and our combined observations follow:

After reading the report we believe that the major question concerns the balance between fundamentals (basic science—engineering science) and specialization (practice). Two quotations from the report lend emphasis to this:

"The instructional goals of engineering education include helping the student to learn to deal with new situations in terms of fundamental principles on his own initiative, and with confidence and sound judgment. The goals should include motivation to keep abreast of the new developments in science and technology, and to continue to grow intellectually in both professional and cultural areas throughout life."

Our feeling about practice coincides with another quotation from the report:

"The engineering art taught in colleges will normally reflect practice that is already, in part, obsolete since teachers' knowledge of practice becomes rapidly outdated."

The Interim Report suggests the time distribution in scientifically oriented engineering curricula as shown below:

(1)	Humanistic-Social	21 semester hours
(2)	Math and Basic Science (about equal in weight)	36 semester hours
(3)	Engineering Science	36 semester hours
(4)	Required Technology	7 semester hours
	Total for the Common Stem	100 semester hours
(5)	Major Departmental Sequence of Engineering Analysis, Design and Engineering Systems	21 semester hours
(6)	Options or Electives in (a) Humanistic-Social, (b) Management, (c) Basic Science, (d) Engineering Science, (e) Research or Thesis, (f) Engineering Analysis and Design, (g) Technology	17 semester hours
	Total for the 4-Year Curriculum	138 semester hours

We were interested to see how the four major schools of engineering in the State of California compared with this proposed course of study. Consequently, we sent for the catalogues of the schools of engineering of California Institute of Technology, University of California, University of Southern California and Stanford University. The point of comparison was to determine whether or not any of these colleges were conducting their schools of engineering along the lines proposed by the report which would mean that approximately three years out of the four would be spent in the area of humanistic-social studies, mathematics, basic science, engineering science and related technology. This would leave a little more than the normal number of semester hours of the year for specialization and optional studies connected with that specialization.

Stanford University closely parallels the time distribution shown in the chart above. The California Institute of Technology approaches the recommendations made above but the general basic courses for all types of engineering are not as

uniform as those of Stanford University. The specialty subjects at the California Institute of Technology are more widely disbursed through the four years than those of Stanford. The University of California and the University of Southern California are farther out of balance between fundamentals and specialization subjects. Except for the University of California the four Universities meet the requirements (total number of semester hours) of the report in the humanistic-social area. None of the schools offered all the work that the report recommends in mathematics, electronics, chemistry and general physics, particularly in the area of nuclear and solid state physics.

It would seem then that Stanford University and California Institute of Technology are attempting to teach the fundamentals with enough specialization so that the graduate would be able to secure and develop on a job.

The report stresses the need for study in the humanistic-social areas of education. We feel that this training is essential to any college graduate. The ability to communicate clearly becomes more important as our society becomes more complex both socially and economically. Training in the principles of human behavior (human relations) is an asset that is recognized in all phases of living.

The report states it is more important that a teacher be an expert in his field than that he have a certain number or kinds of degrees. From our own experience in teaching we can lend wholehearted support to this idea. The instructor whose chief interest is in his subject gives purpose and meaning to his teaching that cannot be accomplished by the "degree collector."

If this new emphasis in engineering will create an inquisitive attitude in students so that they will not "rest on their degree" but will actually begin to become educated as they apply their information and training on some actual job, the idea should have the concentrated support of business and industry.

It was mentioned above that fundamentals change slowly. In education, practice has changed slowly also. We feel that the interim report is an attempt to apply a new workable practice to the old educational fundamentals.

Yours very truly,

K. K. ALLEN,
Manager of
Industrial Relations

To: A.S.E.E. Committee on Evaluation of Engineering Education

The University of Illinois committee has been unable to reach anything approaching unanimity with regard to the major implications of the report, so that it appeared inadvisable to attempt to express a majority opinion. Rather, this preliminary report is intended to present the principal objections raised by various members of the committee and to point up in particular certain phases of the Interim Report which were considered to be ambiguous.

Most of the committee members were in agreement that the manner of implementation of the stated objectives as proposed on pages 21 and 22 does not appear to be consistent with the objectives themselves. Let us assume that a major objective of the Interim Report is a "broadening and deepening of the basic science content throughout all of the scientific and engineering portions of the curricula," to borrow an expression from Secretary A. B. Bronwell. It appears that the intent of the authors is to achieve this broadening by covering in some manner or other the nine topics listed as engineering sciences in addition to adding some material in physics and chemistry. A large portion of our committee seriously doubt that many of the so-called engineering sciences can or will be presented in the manner of a logical development from basic scientific

principles within the span of a single semester course. This is particularly true when such a course is presented by one department for the students in another branch of engineering. Certainly, as now taught, many of such courses do not merit the term "engineering science." There is serious doubt in our minds that the requirement of a number of courses of this type will achieve the type of broadening apparently intended by the statement of the objectives.

Although the Interim Report qualifies its recommendations again and again, it still carries the implication that all engineering curricula should include all nine of the so-called engineering sciences to the extent of a specified minimum in semester hours. This seems to us to be much too restrictive. The impact of a requirement of this type upon certain curricula now accredited by E.C.P.D. would be shattering. In one case, at the University of Illinois, it would require shifting from 15 to 20 semester hours, depending upon the interpretation, from the major field to the engineering science block of courses. Surely, the authors of the Interim Report did not envision this type of emasculation.

The committee is more inclined to favor, instead, a proposal in which any given curriculum might be expected to include perhaps six of the nine topics listed, but with no specification set on the number of hours devoted to each. In June 1954, the University of Illinois College of Engineering adopted a common core including six of the nine subjects listed as engineering sciences, specifying the coverage by topical outline rather than by specification of hours. Moreover, it is reasonable to expect that in a given curriculum considerably more than 6 semester hours of "engineering science" may fall within the major field of specialization. To cite an extreme case, curricula in Electrical Engineering commonly include 15–20 semester hours of basic material on circuits, fields and electronics. It is logical that much of this material should be included in the scientific block of courses. This, of course, means that the "common stem" for all curricula would be reduced somewhat from that recommended.

In order to insure breadth of coverage, however, it could be proposed that each curriculum should include significant offerings of material, presented as a basic science with application to engineering problems, in each of the following areas (over and above the material presented in elementary physics):

1. Mechanics (Statics, Dynamics, Fluid Mechanics, Resistance of Materials)
2. Heat (Thermodynamics, Heat Transfer)
3. Electricity (Electrical Circuits, Fields, Electronics)

The above grouping represents a more appropriate distribution of emphasis, we believe, than the listing of the nine topics separately, as is done in the Interim Report. A fourth group including engineering materials and physical metallurgy was considered but was not included because these topics do not lend themselves as well to presentation as "engineering science." However, with recent rapid advances in solid state physics, the day is drawing near when these subjects can and will be developed in a more logical manner than has been possible in the past. When this is achieved, this area might well be considered to be an additional essential branch of "engineering science."

The term "engineering science" and the listing of the nine topics under that heading has given our sub-committee no end of trouble. In the first place, "engineering science" is defined only by a listing of topics, which, in the minds of some, is no definition at all. Secondly, the topics listed as engineering sciences can be and are being presented variously as basic science, as engineering application of basic science, as the applications of empiricisms, or as engineering art, depending upon the topic and where it is being taught. To many readers, the topics listed will mean courses as they are presented today, and unless it is brought

out forcibly that something else is meant there will be continuing opposition to the inclusion of many of these topics in a listing of "engineering sciences." A clarification of the term "engineering science" would be extremely helpful to the interpretation of the real meaning of the report.

The committee has considered several other phases of the Interim Report, though briefly. There appeared to be general concurrence that the material on selection of faculty was sound, though a few would prefer that less emphasis be given to the importance of the Ph.D. degree in contrast to other measures of competence and potential.

The committee is in general agreement that an additional course in mathematics beyond calculus is desirable for practically all engineering students. There was some belief that the additional course should not be fixed specifically as differential equations, in accord with the view expressed on page 21 of the Interim Report.

It is hoped that the views expressed will be of some assistance to the committee in their revision of the Interim Report.

W. R. CHEDSEY
J. C. DIETZ
V. P. HESSLER
H. H. HILTON
J. E. PEARSON
W. S. POLLARD
C. P. SLICHTER
W. E. BLACK, *Chairman, Committee on Evaluation of Engineering Education*

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTOR AND ASSISTANT OR ASSOCIATE professor for teaching and research in field of metals processing. Courses given in basic and production machine tools. Should be interested in and qualified for some research in metal cutting; capable of guiding graduate students at advanced levels. Salary and rank dependent on education and experience. East. White JA–1.

INSTRUCTOR IN CIVIL ENGINEERING, preferably with M.S. degree and practical or teaching experience; major interest desired but not required—sanitary engineering. Position open fall 1955. Department of Civil Engineering, Rose Polytechnic Institute, Terre Haute, Indiana.

INSTRUCTOR OR ASSISTANT PROFESSOR with M.S. in Civil Engineering to teach surveying, soil mechanics, fluid mechanics, and normal civil engineering laboratories. Should be active in technical and professional organizations. Salary and academic rank open depending on degree and experience. Position starts September, 1955. Location, Ohio. Write JA–2.

ASSISTANT OR ASSOCIATE PROFESSOR in Electrical Engineering with an advanced degree and experience, to teach in the power field. Should be active in technical and professional organizations. Degree and experience to determine academic rank and salary. Position starts September, 1955. Location, Ohio. Write JA–3.

Teaching Positions Available are also listed on Page 430

Report on the Carnegie Conference on the Impact of Solid State Science on Engineering Materials

By GLENN MURPHY, *Conference Secretary*

Professor and Head of Aeronautical Engineering, Iowa State College

Representatives from about 45 colleges and universities and from nearly a score of industrial and government organizations met at Carnegie Institute of Technology, 21–25 June, 1954 to discuss the latest developments in solid state science and to consider the ways and means of incorporating these developments into engineering curricula. The conference was sponsored by Carnegie Institute of Technology, 21–25 June 1954 to discuss the the active cooperation of the National Science Foundation and ASEE. Assistant Dean J. W. Graham and Prof. J. E. Goldman were the conference chairmen. General plans for the meeting had been made at the Allerton conference in March.*

The papers that were presented on the technical phases of the developments in solid state science are scheduled to be published early in 1955 in a volume edited by Professor Goldman. The presentations included discussions on the Structure of Matter by Prof. Harvey Brooks of Harvard and Prof. J. Bardeen of the Univ. of Illinois; Phase Transformations and Their Influence on Metallic Properties by Prof. H. Jones of Imperial College and Carnegie Inst. of Tech., with Applications of Modern Theory of Metals by Prof. R. Smoluchowski of Carnegie Inst. of Tech.; Surface Effects and Properties by Prof. R. Gomer of the Univ. of Chicago; Introduction to Dislocations and Plastic Theory by Prof. Smoluchowski, Plastic Properties by Prof. H. Paxton of Carnegie Inst. of Tech., Phase Transformations by Prof. T. A. Read of Columbia Univ., and Grain Boundary Effects by Prof. Earl Parker of the Univ. of California. The session on Magnetic Properties included papers by Prof. Goldman and Dr. R. M. Bozorth of Bell Telephone Labs. A paper on Semiconductor Theory by Prof. K. Lark-Horowitz of Purdue was given by Prof. B. R. Gossick, followed by a discussion of Applications to Engineering Devices by Prof. W. J. Leivo of Carnegie Inst. of Tech. Dr. Harrison Davies of Mellon Institute talked on Glass Science and Technology. A discussion of the Theory of the Properties of Plastics and High Polymers was presented by Dr. T. Alfrey, Jr. of Dow Chemical Corp. and the final technical paper of the conference was on the Physics and Chemistry of Cements by Dr. S. Brunauer of the Portland Cement Association.

The keynote of the educational aspects of the problem was struck by Dean B. R. Teare, Jr. in his opening remarks. He stated that the purpose of the conference was to review the content of solid state science in relation to materials, to consider what this science has to offer engineers and to help determine what place

* A Report on the University of Illinois Summer Institute Conference on Solid State Physics in the Engineering Curriculum, Glenn Murphy, *Journal of Engineering Education*, **44**: 494–498, May, 1954.

it should have in engineering education. He indicated six groups of pertinent questions.

1. What are the essentials of solid state physics as they relate to engineering education?
2. How can they best be taught, by whom, at what level, in what year, for how many credits and with or without laboratory?
3. How can solid state science be utilized in subsequent engineering courses to realize its full value?
4. What prerequisites in mathematics and physics are needed?
5. What special difficulties are likely to be encountered?
6. How can space and time be found in curricula for this material?

Formal discussion of these and allied questions took place at two sessions during the latter part of the conference following most of the technical presentations.

Taking part in the discussion of the educational aspects were representatives of curricula in aeronautical engineering, ceramic engineering, civil engineering, chemical engineering, electrical engineering, engineering mechanics, mechanical engineering, metallurgical engineering and physics. There were more representatives from physics departments than from any other department, with electrical engineering second. The other curricular departments were about evenly divided in representation.

Recurrent Theme

Throughout the open discussion there was the recurrent theme that the engineering developments of the next quarter century or more will be closely linked to the research that is being done today and that those phases of research that will contribute to a better understanding of materials are of prime importance. In addition, it was apparent that there existed an appreciation of the fact that the present limitations in many engineering developments is a direct result of the limitations in our knowledge of the properties of materials, and that those concepts and principles useful in explaining or pointing toward an explanation of how materials will behave in stress, electrical or magnetic fields are particularly significant in engineering at the present time. An undertone of urgency was apparent—an expressed indication that immediate attention needs to be given to incorporating the concepts and principles into some of those curricula where they do not already exist. On the other hand, is was clearly recognized that extensive training in solid state physics would be justified for only a small percentage of the engineering students, and that it would not be desirable at the present time to introduce a required course in solid state physics at all schools and in all curricula.

However, all of those who spoke in the open discussion favored the inclusion of at least some aspects of solid state science in engineering curricula, thereby confirming the resolution passed at the Allerton Conference. From the discussion it was evident that the term "solid state science" was being used to refer to the group of concepts and principles essential as a basis for explaining or pointing toward an explanation of the behavior of materials in stress, electrical or magnetic fields. Several speakers indicated that the principles have already been incorporated into existing engineering programs, particularly in electrical and metallurgical engineering. In a few instances an introduction to the field is being given to all engineering students in the general physics courses.

During the discussion it was brought out that there are four ways in which these concepts and principles may be made a part of the training of the engineering student. These are (a) the enrichment of existing courses in the various curricula, (b) the replacement of a specific portion of present appropriate courses with up-to-date material, (c) the utilization of available courses (generally in physics) as electives, and (d) the establishment of specific new courses in solid state physics or solid state science.

By the enrichment of existing courses is meant the use of appropriate examples to illustrate the application of the principles to the subject matter of the course under consideration. For example, in a course in machine design the subject of work hardening of metals during fabrication might be introduced as illustrating a concept of how dislocation theory is related to the alteration of the mechanical properties of metals. From the standpoint of the curriculum builder, this approach appears to offer certain advantages. It puts the material before the student without having to drop any technical specialties or cut short the social-humanistic percentage of the curriculum. It also strengthens the tie between principles and their applications in various courses and this is good. However, there are two weaknesses to this approach. One is that it assumes that each instructor is familiar with the principles under consideration, and the other is that even it he does know the principles that he will be willing to displace other examples and illustrations of other principles that he wishes to stress in order to introduce a consideration of concepts which frequently are qualitative rather than quantitative.

Certainly much can be done with this technique, and it may be used to great advantage in helping to answer questions that arise in class. In fact, it will often be more meaningful when utilized in that way. Effective use of the technique is dependent upon the instructor's knowing just what the student has had in his prerequisite science courses, and this information can be developed through interdepartmental committees. At least one university has set up groups of interdepartmental committees which are helping to achieve closer cooperation between science and engineering.

The second technique, that of replacing a specific portion of present courses with appropriate material in the field, is likewise attractive from the standpoint that it does not involve discarding favorite advanced specialities in any curriculum. Certainly two weeks' time can be gained in the average course in engineering materials by discarding unessential descriptive material thereby providing an opportunity to introduce some solid state physics. The method of replacement has been used in electrical engineering curricula at various schools to make space for a brief treatment of semiconductors and their applications in transistors. More solid state science can be introduced into metallurgy courses in this way.

One question to be raised in conjunction with the partial replacement approach is whether a period of perhaps two weeks is adequate to permit a fundamental approach or whether that length of time is adequate only for a few examples. The answer to the question must be considered in the light of the extent of prerequisite courses.

Elective Courses

Elective courses in solid state physics are available at a number of schools, usually in the physics department but in a few instances in engineering. The indications at the Carnegie Conference, as at the Allerton Conference, are that very few engineering undergraduate students elect such courses. For those students contemplating advanced study with a career in research, an undergraduate course in solid state physics appears highly desirable. However, at the time that there is an opportunity to elect such a course, the student can hardly be expected to have made an unalterable decision to enter research. Another disadvantage inherent in the exclusive use of the free elective system for providing the training in solid state physics is that the subject matter is off the beaten track for the majority of students, and only a relatively small number will have the opportunity of learning of its potentialities.

The establishment of new courses in solid state science for engineers was cited as the fourth method of introducing the subject matter into the various curricula. These could be in the form of a general

course for all engineers with the contents approximately as outlined at the Allerton Conference and extending over one or two semesters, or they could be in the forms of more specialized engineering courses similar to those being taught at some universities.

The introduction of a new required course automatically raises the question of what it will necessarily displace. Suggested answers to this question may be classified into three groups. One solution is to drop a free elective, a technical specialty or a course concerned with those aspects of the art of engineering that are in all probability obsolete before they reach the student in a textbook. A second possible solution lies in the elimination of duplication. Possible duplication between the work taught in physics and the various engineering departments in the subject field of mechanics, thermodynamics, and electricity and magnetism have been cited for consideration. The question of the importance of differences in viewpoint and methods of approach in the various departments must be carefully considered before wholesale removal of courses is warranted. The third class of solutions includes those related to an increase in teaching efficiency. In some instances it may be possible to telescope sequence courses, thereby gaining some time, through elimination of unnecessary detail in each and through more effective teaching.

Related aspects, including an indication of a sincere desire to give the student the best possible education during his college career, are evident from the following ideas expressed during the open discussion.

"At present there are relatively few examples of the application of solid state physics, but it is important to develop in the undergraduate a point of view so that he can recognize the elements of the problems he will later meet."

"A better understanding of materials could be built up if the students had more solid state physics—but we must not neglect the art of engineering. Chemistry, physics and mathematics all should be re-evaluated."

"The why of phenomena as well as the how must be part of the approach in basic courses."

"The elementary course must be qualitative rather than quantitative in nature, and should not replace the conventional elementary physics."

"More time could be spent on thermodynamics, bond theory, valence and bonds early in chemistry to lay the basis for later applications."

"Relatively little theory should be introduced in an elementary course, but an understanding is important."

"Part of the approach in a basic course is to develop a feeling on the part of the students for the order of magnitude of various effects."

"A suitable course can be introduced at the undergraduate level."

"It will be hard to lay out a single program suitable for all engineering students."

"The subject matter outlined in the Allerton Conference report can be added to the students' program provided they have a sound basis in chemistry and mechanics. The exceptions and limitations can be treated in later courses."

"The material outlined at the Allerton Conference should be covered in two sophomore courses in physics and should prepare the graduate to read the current literature in the field."

"Once a few schools start using solid state physics in engineering curricula, others will follow."

"Engineers would like to see a method developed for getting from the structure of a crystal to the stress-strain diagram at a given temperature."

"One possibility is to introduce a survey foundation course to point out the modern viewpoint and then to extend the treatment in later courses."

"With four semesters of physics required for engineers, Rensselaer has a course similar to the introductory course

outlined in the report of the Allerton Conference. This introduces the basic background of solid state physics but cannot give a quantitative treatment at the undergraduate level. The entire fourth semester is devoted to modern physics with particular emphasis on engineering."

"The principal problem is that of educating the faculty."

General Agreement

From the information on existing courses and from the ideas expressed in the discussion (of which the foregoing are only samples) it was apparent that there was general agreement with the recommendation of the Allerton Conference that work in solid state physics be introduced into the engineering curricula, and it was also apparent that no one of the plans outlined was predominantly favored over the others. There was general agreement that the selection of the plan or combination of plans at a given institution must be governed by the institution, the objectives of the individual curricula and the interests and aptitudes of the staff members concerned.

It was voted to recommend that item III of the resolution adopted at the Allerton Conference be amended to read

"that the implementation of these objectives be achieved through the cooperative efforts of engineering and science departments at each institution."

In closing the conference Dean R. F. Mehl of Carnegie Institute of Technology pointed out the revolutionary impetus that had been given to metallurgical engineering twenty-five years ago by the introduction of the concepts of chemistry and solid state physics, and indicated that a similar impetus was available in the other engineering fields through the application of solid state principles and concepts. He advised that the material not be isolated in a single course, but be introduced wherever possible in the various engineering courses where it applies.

A vote of thanks to Dean Teare, Asst. Dean Graham, and Prof. Goldman of Carnegie Institute of Technology, to the lecturers, and to the University of Illinois, the National Science Foundation and ASEE for organizing an extremely stimulating conference was heartily approved.

College Notes

A $250,000 Ford Foundation grant to **Carnegie Institute of Technology** was announced. The grant will be used in Carnegie's Graduate School of Industrial Administration to finance fellowships for men looking toward careers in teaching and research in industrial administration. Activities under the new grant will supplement the Graduate School's basic objectives of training men for careers in business and industry, and its present research into the behavior of business organizations, effective decision making, operations analysis, and related areas. The new $250,000 grant supplements earlier Ford Foundation awards of $167,000 to Carnegie's Graduate School of Industrial Administration for research into more effective business organizations and decision-making.

Mathematics for Graduate Work in Engineering*

By JOHN W. CELL

Professor of Mathematics, North Carolina State College

Since much advanced mathematics is necessary to the understanding of graduate work in any field of engineering and to the reading of technical papers in that field; since much basic but advanced physics and engineering is likewise needed; and, further, since the study of mathematics must include derivations, illustrations, and applications; therefore required instruction in mathematics for advanced undergraduate and graduate students in engineering must be different from that given to students of pure mathematics. This does not mean that such courses in applied mathematics would lack rigor. This does imply that the material in any one topic must be less comprehensive than that given in specialized courses in pure mathematics.

What is pertinent background in which to consider this required mathematics? In the first place ours is a period of experimentation in education at all levels and in all areas. There is more to learn in any one field today than there was twenty years ago and the content continues to grow. Because this is especially true in mathematics, committees from the Mathematics Association and the National Research Council are at work in the study of both content and objectives of the mathematics for high school instruction and for that normally studied in the first two years of college mathematics. In high school curricula some experimentation is underway, for example, to combine plane and solid geometry into a single-year course and to spend the gained semester on other mathematics. The experiments being conducted at the University of Illinois in improving high school instruction for prospective engineering students are being watched with great interest. At the college level the growing emphasis on the teaching of a combined course in analytic geometry and calculus is a part of this experimentation and is reflected in the number of textbooks now available for this type of course.

One aspect of this experimentation concerns motivation. In colleges where calculus is used in the instruction in physics and where the teaching of mathematics and physics is somewhat correlated, there is an automatic motivation for the student in his study of mathematics. This motivation is necessary if students are to learn elementary mathematics and not merely earn course credits. Engineering problems courses for freshmen engineering students can greatly aid in this motivation.

In colleges where mathematics is really used in the junior and senior courses in engineering instead of being avoided, motivation for the study of mathematics is transmitted by the upperclassman to the freshman and sophomore. Such utilization of mathematics at the upper level can serve in other important ways. Let me illustrate with the question of beam problems in strength of materials. Here the electrical engineering student would gain significant background for his later study in transients if the beam problems were solved by the double-integration method.

* Presented at the Mechanics Summer School sponsored by A.S.E.E. at Urbana, Illinois, June, 1954.

	Bronwell	Franklin	Guillemin	Hildebrand	Kaplan	Karman and Biot	Margenau and Murphy	Murnaghan	Pipes	Reddick and Miller	Reed and Reed	Schelkunoff	Smith	Sohon	Sokolnikoff	Wylie
Infinite Series	x	x		x	x				x	x		x	x		x	x
Fourier Series	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fourier Integral	x		x	x			x		x				x			x
Determinants and Matrices			x			x	x		x		x		x	x	x	x
Solution of Equations	x					x			x		x	x		x	x	
Ordinary Differential Equations	x	x		x	x	x	x		x	x	x	x		x	x	x
Partial Differentiation, etc.	x	x			x		x		x	x		x	x		x	x
Multiple Integration, Improper Integrals, etc.		x		x	x							x	x		x	x
Finite Differences, Interpolation						x			x					x		
Elliptic Integrals	x	x		x		x	x			x			x		x	
Gamma, Beta, Error Functions, etc.		x		x			x		x	x		x	x	x		x
Bessel Functions	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Vector Analysis	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
Partial Differential Equations	x	x		x	x		x	x	x	x	x	x		x	x	x
Complex Variables	x	x	x	x	x				x	x	x	x	x			x
Operational Mathematics	x		x	x		x	x	x	x	x	x	x	x			x
Empirical Formulas, Curve Fitting, Numerical Methods							x					x			x	x
Calculus of Variations		x					x	x	x				x			
Probability										x			x		x	
Space Geometry		x			x		x					x	x			
Integral Equations							x	x					x			
Tensor Analysis													x			
Nonlinear Problems									x							
Linear Transformations			x										x			
Quadratic Forms			x					x					x			
Orthogonal Functions			x	x	x								x			
Partial and Continued Fractions			x								x					
Dimensional Analysis														x		

Advanced Mathematics in Physics and Engineering by Arthur Bronwell (Electrical Engineering), McGraw-Hill, 1953

Methods of Advanced Calculus by Philip Franklin (Mathematics), McGraw-Hill, 1944

The Mathematics of Circuit Analysis by E. A. Guillemin (Electrical Communications), John Wiley and Sons, 1949

Advanced Calculus for Engineers by F. B. Hildebrand (Mathematics), Prentice-Hall, 1949

Advanced Calculus by Wilfred Kaplan (Mathematics), Addison-Wesley, 1952

Mathematical Methods in Engineering by T. Karman (Aeronautics) and M. A. Biot (Mechanics), McGraw-Hill, 1940

The Mathematics of Physics and Chemistry by H. Margenau (Physics) and G. M. Murphy (Chemistry), Van Nostrand, 1952

Introduction to Applied Mathematics by F. D. Murnaghan (Mathematics), John Wiley and Sons, 1948

Applied Mathematics for Engineers and Physicists by Louis A. Pipes (Electrical Engineering), McGraw-Hill, 1946

Advanced Mathematics for Engineers by H. W. Reddick (Mathematics) and F. H. Miller (Mathematics), John Wiley and Sons, 1947

Mathematical Methods in Electrical Engineering by Myril B. Reed (Electrical

The other two methods could then be left to a second course in strength of materials or to a succeeding course in civil engineering where students would learn these useful concepts. The neglect of the double-integration method is an evidence that all of us tend to teach our courses as though all our students were majors in our particular fields.

More Emphasis on Understanding

Motivation is inseparable from good teaching and intelligent study. Good engineering students should not be "cook-book specialists" in mathematics; mathematics is more than formulas in a handbook! Instruction in mathematics should be divided between theory, drill problems, and applications. More emphasis should be placed on understanding and less on memorization, and time should be given to formulation of problems. Professor Meriam of the University of California states that "instruction in mathematics is generally weak for its scanty emphasis on the formulation of problems"; and other prominent engineering teachers have made the same contention.

Prospective graduate students should as undergraduates take more mathematics and physics than the present minimum requirement. Courses such as the one in engineering problems at Carnegie Institute of Technology for juniors and seniors in electrical and mechanical engineering can aid greatly in developing mathematics beyond calculus. Dean Teare of that institution writes that "the how of teaching (1) should help the student learn to analyze problems that are new to him with well-ordered thinking and (2) should prepare him to go on learning in the field of mathematics on his own initiative and without the guidance of a teacher."

The usual two years of required mathematics for engineering students, however, is decidedly inadequate. Professor Pletta of Virginia Polytechnic Institute writes that such students are "absolutely illiterate technically and unable to read the literature in any field without the equivalent of four years of mathematics." If additional mathematics cannot be given to all of the engineering students, at least there should be some method found to distinguish prospective graduate students among the rising juniors and to give them additional mathematics and physics in their undergraduate work.

These students should take at least one additional year of mathematics in their undergraduate programs if they are to derive maximum benefit from their early graduate study. Before discussing the content of that year course let us compare the content of a number of available texts, as shown on the next two pages. Some of these are written by electrical engineers, some by physicists, some by mathematicians, and one by an aerodynamicist and an engineering mechanics professor. Some of these are unfortunately of the cook-book variety; others, however, give a more balanced treatment of mathematics and applications.

An analysis of these texts will show agreement that this year of advanced undergraduate mathematics should contain

a. Elementary ordinary differential equations,
b. Infinite series,
c. Fourier series,
d. Bessel and related functions,
e. Vector analysis,

Engineering) and Georgia B. Reed (Electrical Engineering), Harper and Brothers, 1951

Applied Mathematics for Engineers and Scientists by S. A. Schelkunoff (Technical Staff of Bell Telephone Laboratories), Van Nostrand, 1948

Mathematical Methods for Scientists and Engineers by Lloyd P. Smith (Physics), Prentice-Hall, 1953

Engineering Mathematics by Harry Sohon (Electrical Engineering), Van Nostrand, 1944

Higher Mathematics for Engineers and Physicists by Ivan S. Sokolnikoff (Mathematics) and Elizabeth S. Sokolnikoff (Mathematics), McGraw-Hill, 1941

Advanced Engineering Mathematics by C. R. Wylie, Jr. (Mathematics), McGraw-Hill, 1951

f. Partial differentiation and elementary partial differential equations,
g. Integration including multiple integration and improper integrals.

It is my contention that this is enough material for a one-year course if it is correctly taught. In the first topic I am supposing that trick method of solving special differential equations have been omitted from this course. Linear differential equations with constant coefficients are to be emphasized and particular solutions are to be obtained by several methods, including that of variation of parameters. The portion on differential equations should also include series solutions and brief attention to graphical and numerical methods of solution. Finally, I am supposing that differential equations are carefully derived from physical problems, solved by appropriate methods, and the results interpreted in terms of the given problem. The same type of comment applies to the material of the other six topics.

Modifications of this content would be made at some colleges where there are exceptions to customary practices. For example, if elementary mechanics is taught by vector methods, as is being done, for example, at Cornell University and at Carnegie Institute of Technology, vector analysis in the proposed course could be either compressed or eliminated.

The discussion thus far has been devoted to background and to this one-year advanced undergraduate mathematics course. Let us next consider the content of three one-year courses at the graduate level in mathematics. The first of these would be required of master's-degree students and the other two additionally would be taken by Ph.D. students. As we discuss these courses, we must consider not only their present adequacy but also their value for the next ten years. It is pertinent to call attention to the joint committee from the American Mathematics Association and the American Society of Engineering Education under the chairmanship of Dr. G. B. Thomas, Jr. of M.I.T. This committe is studying the content and objectives of engineering mathematics at the undergraduate and graduate levels and is to make recommendations for improvement.

Among these newer requirements, the solutions of non-linear problems and of more complicated ordinary and partial differential equations are of increasing concern in many branches of engineering. Methods of solution embrace numerical methods such as the relaxation method, and the growing use of analog and digital electronic computers. Parenthetically, the need in the next two or three years for between one and two thousand applied mathematicians to man these electronic computers is allied very closely with this discussion of course content and course objectives.

With this overall background we may now consider these three one-year graduate courses in detail.

1. The first one-year course would consist of
   a. Complex variables including conformal mapping and residue theory;
   b. Operational mathematics including not only Laplace transforms but also the various Fourier transforms, Hankel transforms, and finite transforms;
   c. Solution of problems in ordinary and partial linear differential equations.

This course would include derivations in mathematics. For example, I would derive the usual Cauchy equations for an analytic function. But I would merely outline the proof of the fundamental Cauchy theorem about the integral of an analytic function around a simple closed curve and would not go through the detailed derivation.

This course would emphasize total problems; that is, their formulation, their solution, and their implications. Partial differential equations would be carefully derived by both the delta and the differential languages and would be solved by appropriate methods such as separation of variables and transform methods; the im-

plications of the solutions would be discussed. In some cases the formally obtained solutions would be verified carefully, and in other cases this step would be waived.

The various fields of engineering and science provide sources of total problems. For instance, applications of conformal mapping would be made to field problems such as those in fluid mechanics. Transform methods would be applied to solutions of problems in ordinary and partial linear differential equations, to integral equations, and to difference equations. Boussinesq's results in elasticity, for example, are solutions of partial differential equations obtainable by these transform methods. (Drill in residue theory would occur in obtaining inverse Laplace transforms of partial differential equations.) Problems in wave motion, heat and diffusion, and in elasticity would be solved as partial differential equations.

Among the appropriate texts for this course are the three books by Professor R. V. Churchill on *Complex Variables, Modern Operational Mathematics in Engineering,* and *Boundary Value Problems,* all published by McGraw-Hill; and the pocket-sized book by C. J. Tranter on *Integral Transforms in Mathematical Physics,* published by John Wiley and Sons.

2. A second one-year course would include the following topics:
   a. Determinants and matrices,
   b. Advanced vector analysis,
   c. Tensor analysis,
   d. Space geometry.

To avoid repetitiousness I shall omit from the discussion of the other two year courses all but a brief mention of their applications.

Applications of determinants and matrices would be made to stability criteria (e.g. Routh's), to solution of simultaneous equations, to the concepts of superposition and reciprocity, etc. Applications of tensor analysis in elasticity are readily available.

3. The third one-year course would include
   a. Calculus of variations,
   b. Integral equations,
   c. Finite differences and difference equations,
   d. Perturbation methods of solution and advanced boundary value problems,
   e. Numerical methods,
   f. Non-linear problems.

Applications of these topics would be made appropriately and need not be detailed here.

In both the second and third courses some of the mathematics would be presented rigorously and some would be given in less detail. Applied problems would include formulation of the mathematics problem, the solution of that problem by one or sometimes two methods, and an analysis and interpretation of the results.

Textbooks such as *Methods of Applied Mathematics* by F. B. Hildebrand of M.I.T. (Prentice-Hall, 1952), *Mathematical Methods for Scientists and Engineers* by L. P. Smith of Cornell University (Prentice-Hall, 1953), and *Applied Mathematics for Engineers and Scientists* by Schelkunoff (Van Nostrand, 1948) could be used appropriately for some of the material of the second and third courses. But more such books are urgently needed.

Summary

Let me summarize briefly.

One year of advanced undergraduate mathematics and three one-year courses of graduate work have been outlined as required material for Ph.D. students in engineering; half of this would be required of master's-degree students. These courses would include some mathematics rigor, they would be less comprehensive of individual topics than is traditional in mathematics, and they would include the study of total problems: formulation, solution, interpretation. It is my conviction that the proposed courses provide in Dean Teare's words "root concepts on which further education can be built."

Progress in Teaching English to Engineers*

By C. A. BROWN

Chairman, English Department, General Motors Institute

Testimony that engineering graduates must have command of the arts of communication is not lacking. Employers are perfectly willing to make statements to that effect. All of us can collect an imposing array of such statements, some critical, some helpful. On the other hand the evidence in engineering journals is that engineers do write. Some of them write quite well.

In the face of criticism, however, almost instinctively our defenses bristle. We talk about inadequate preparation on the part of students, inadequate professional opportunity for teachers, inadequate time provided for the proper courses, and so on. While some of these reasons may be appropriate in some institutions, I am convinced that our real problem for a long time was the lack of communication between the English departments on the one hand and the engineering faculties and industrial employers on the other. Some of the responsibility rests upon industry, but certainly some of it rests upon us.

I can illustrate from the broader problem of engineering education and the extent to which it does or does not fill the needs of industry. There are some in industry who have been critical of the engineering graduate because "he can not do anything." They have attempted to apply pressure upon the engineering colleges to equip graduates with specific skills so that they will be immediately useful to their employers. This would lead to some form of training other than professional education as I understand it. Fortunately most of our engineering colleges have resisted this pressure.

Others have insisted that the engineering graduate know "the fundamentals of engineering." Upon this foundation each industry would train or educate the graduate in the applications of those fundamentals in the particular industry in which he is employed. Now the problem becomes one of agreeing upon what constitute the fundamentals. That problem, in engineering education, is being solved.

The desire to have college graduates who can write and speak clearly reflects some of the same confusion. Some industrialists want engineering graduates trained to write a particular kind of report. Others insist upon "fundamentals." Apparently they believe that each graduate should be supplied with an orthodox set of formulas for preparing reports that will meet specific situations. Industrialists' ideas of what constitute fundamentals are not necessarily the same fundamentals that English teachers are thinking about. Since most of the men in the employing situation are old enough to have been reared and educated with a background of certainty as to what is "right," they want young men who can use "correct" grammar, "correct" spelling and "correct" sentence structure. They do not relish any discussion, no matter how fascinating it is to the English teacher of the differences between prescriptive and descriptive grammar. They are not interested in semantics as a substitute for composition. Our concept of fundamentals is not always in accord with those of employers.

Each of us can illustrate from his own experience other instances of misunder-

* Presented at the annual meeting of ASEE, English Division, University of Illinois, June 15, 1954.

standing between those of us who teach the engineer and those who utilize his services. Fortunately a great deal of this misunderstanding has disappeared. The tone of the papers today is very different from that of twenty years ago. Certainly our understanding has increased considerably.

Significant Developments

I should like to suggest then the following ways in which this understanding is being developed:

1. One of the strong influences for the better has been the advent of the humanistic-social studies program in engineering education. You will recall that the report on engineering education in 1940 set up two stems: the scientific-technological and the humanistic-social. With the establishment of the Humanistic-Social Division of the ASEE in 1944, there was a greatly stimulated interest in the non-professional courses for engineering students. Many schools enlarged their programs, in a few cases perhaps at the expense of English courses. In most of the schools, however, I believe that the creation or renaming of courses in line with the 1940 report actually improved the status and prestige of the English teachers. The real extent of this influence will not of course be known until the study of humanistic-social programs has been completed.

2. We have had further reinforcements from the College English Association. In the past few years, CEA has been interested in the preparation of college graduates to enter business and industry. The original stimulus was to prepare English majors for occupations other than teaching. Now, however, the scope has broadened to include the non-science liberal arts courses as well.

Several English-Industry Institutes have been held to promote the understanding between people of industry and the college faculties. The latest was held last fall at the Corning Glass Center. A number of the papers that were read at that meeting were reprinted in *The Saturday Review*. You will also recall that we held a joint meeting with the CEA last year at the University of Florida. Another is to be held next week at Michigan State College. We are certainly pleased to have teachers of English in the traditional liberal arts colleges interested in preparing people for a realistic and worthwhile life even though they are English majors.

In other words, the trend is toward a greater and more realistic understanding of the needs of college graduates and the consequent adaptation of courses to that end.

3. For as long as I can remember there has always been an interest on the part of the engineering faculty in having graduates speak and write with the skill and grace expected of any college graduate. Gradually the English teachers and the engineering teachers have been getting better acquainted. Each has been winning the respect of the other.

This increased understanding has led, of course, to greater cooperation which has manifested itself in different ways. For example, in some schools there has been an increase in the advanced courses given to engineering students. Some of these are specialized courses in report writing. Not so many years ago there was a very strong conviction in engineering schools that report writing was an engineering subject that should be taught by engineering teachers. One reason why report writing courses were set up and taught by engineering faculties in some schools was that the English teachers did not respond to the occasion. In more and more schools report writing is now being taught by the English staffs. This has led to various experiments in joint efforts. One was reported at our meeting in Florida last year. Another was reported in a recent issue of the *Journal of Chemical Education*. Each of us can cite examples from our own schools.

Another joint activity has been that of withholding credit in English composition courses until graduation. Papers submitted in courses other than English are read. If the quality of writing is not that

expected of a person who should have established his right to credit, he may be required to take remedial work in English. In the schools that I know of where this plan is in operation, the stimulus came from the engineering faculty and invariably the chairman of the activity is a professor of engineering.

4. English teachers themselves are finding that there is a satisfactory career in teaching engineering and business administration students. Apparently they feel that their efforts are being appreciated. Apparently also there is an increasing emphasis upon the skill and art of teaching so that rewards of prestige, status, and salary come to those who teach as well as to those who publish.

They are seeking and receiving the equivalent of fellowships in business and industry. In the urban areas they are taking advantage of consultation work and teaching in industrial concerns. Sometimes these were undertaken purely as a means of augmenting income, but I know that in a great many cases these activities have grown into a major interest.

There are other indications that efforts are being made and that results are being obtained. I have presented these four as being the ones that are the most significant.

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTOR IN ELECTRICAL ENGINEERING on or before February 1, 1955: One familiar with electric power and electronics; preferably some industrial experience. Good opportunity for advancement. Franklin Technical Institute, 41 Berkeley Street, Boston 16, Mass.

AN INSTRUCTOR IN ENGINEERING Drafting and Machine Design on or before February 1, 1955: One thoroughly familiar with theory and practical design who has had some industrial experience. Opportunity for advancement. Franklin Technical Institute, 41 Berkeley Street, Boston 16, Mass.

INSTRUCTORS: TO TEACH ENGINEERING Drawing and Descriptive Geometry at Texas A. & M. College, College Station, Texas. Appointment effective September 1, 1955. B.S. Degree in Engineering and teaching experience desired. Opportunity to do graduate work. Submit record of education and experience to W. E. Street, Head Engineering Drawing Department.

PROFESSOR AND HEAD OF DEPARTment of Electrical Engineering, University of Rhode Island, Kingston, Rhode Island. Five other staff members. Graduate work leading to master's degree. Opportunities for research and consulting work. Apply to Dean, College of Engineering.

Teaching Positions Available are also listed on Page 417

Our Schools Can Teach Writing—If They Are Made To

By J. H. WILSON, JR.

Editorial Branch, U. S. Naval Ordnance Test Station

Our schools do not teach writing. Let's grant that to begin with. Our schools do not teach writing; they do not teach technical writing. They do not teach writing because they have not been made to. They will teach writing when they are forced to. And one very potent voice in the cry and hue that our schools begin to teach writing is that of research and development organizations employing graduates of our technical colleges or our universities.

An increasing number of industrial research and development organizations are being forced to give a course in report writing to their scientists, engineers, and technicians. Professional technical writers or editors may be brought in for the assignment, men employed in the company's writing or editorial unit; university professors may be brought in, often from some distance and at considerable expense; or, more expensive yet, a "writing consultant" may be called in. In a large organization where new men are always coming in, where men are being promoted or reassigned to jobs in which they will have to write reports, this training in report writing must be a perpetual process! While all this training is going on, management must look on and wonder whether it is really worthwhile, whether any good comes of the course, whether all the money this attempt to teach decent report writing costs is going to profit the organization. For the process of trying to teach report writing is expensive. There is first of all the cash outlay if a man is brought in on contract solely to teach a reports course; and if a man already employed is assigned to teach the course, his time, and the time of the men taking the course is lost productively. Inevitably management must ask:

"Why do we have to teach our people to write reports? Why don't our colleges teach our technical people to write reports?"

It is a fair question. Why don't our technical schools teach our technical people to write reports? Why don't engineers and scientists learn to write someplace down the line in the sixteen years or more they've been in school? It is the contention of this paper that writing is not taught in our schools because industry, commerce, business, and government, all the agencies which use the products of our schools, have not demanded that writing be taught in the schools.

The ability to write easily, quickly, and clearly is a vital part of the well-qualified technical man's equipment. At least it should be. Technical men, however, are notoriously inept at writing; so notorious that a technical man who does write with ease, with vigor, and above all, with clarity, is an anomaly. I have on my desk right now a paper by an exceedingly able mathematical physicist, sent back by a journal for "a little editorial straightening out" as "suggested" by the comment sheet. The journal bounced the article because it was unreadable, though technically acceptable. It is so garbled that no less than a complete rewriting is called for.

Whether the inability of technical men to write can or cannot be cured once they

are out of college, the finger of blame for this incompetence in writing must point to our schools, to the technical colleges which turn out our technical men.

Two Basic Problems

At least two basic problems are involved in teaching technical people to write reports—in school or after. First there is the rock-bottom problem of teaching them to write. Secondly there is the problem of teaching them to write technical reports.

To take the this-above-all problem of teaching writing. The idea is abroad, and finds support in the highest circles, that writing can no more be expected of college graduates than piano playing. Witness Barzun's article in the December 1953 *Atlantic*, "English as She Is Not Taught." Granted, if you are talking about "creative writing"; good creative writers are even fewer than good bistro pianists. But writing that is a skill, that is a mere putting down on paper of organized thoughts and ideas, experiences and experiments, can be taught to people who have enough on the ball to get through college. Writing can be taught just like we learn to talk—by practice. You can teach almost anybody who can graduate from high school to write just like you can teach them carpentry and bricklaying, chemistry and physics, arithmetic and algebra. You can teach the basic skill of writing. Any teacher of writing knows this. An editor here in the office who teaches a night class in writing said only this morning:

"One person in my class has talent. The rest I'm just teaching to write."

Once the notion is overcome that a god-given gift for writing is required to write technical reports, and it is recognized that the problem is simply that of teaching a skill, the factor of time required to teach this skill raises its hooded head. The press of a thousand other activities militates against a decent job of either teaching or learning to write technical reports in college or after.

What militates even more against adequacy in report writing is the attitude that writing is something that must be done, but really isn't too important anyway, and we shouldn't spend any more time on writing reports than the absolute minimum. There is work to be done, let's get something, anything, scribbled down and published. Despite the fact that a technical man's professional advancement depends so vitally on the papers he must publish, the general attitude toward report writing, toward all "paper work" is one of depreciation. Confronted with the fact that ours is a literate, a "paper" civilization, where in the long run the papers written and published are at least as important as anything materially produced, this looking down the nose at reporting and "paper work" is self-annihilating.

Learning to write takes time, and effort, and practice. The longer the practice, generally, the better the writing. That means that to teach writing as a skill in which high competence is expected, writing practice must begin young and continue over all the school years—grade school, high school, college.

But you can't expect grade-school or high-school students to be saddled with homework! You can't expect them to be saddled with a weekly essay through grade school, high school, and even college! Our civilization may depend on literacy—and that means writing no less than reading, since writing is the primary means of recording our culture—but the discipline of learning to write is too much to expect of our children. (And psychologists and educators are finding that grade school, high school, and college students, and adults are not much better at reading than they are at writing.)

The gist of this harangue is that writing as a skill depends upon inculcating writing habits, and writing habits can only be built up by years of conscientious effort. Learning grammar, however fundamental, will not teach you to write. Only writing will teach you to write. Why is it that so many of your technical writers and

editors are technical men who somehow always got stuck with writing reports? They got into the habit of writing! They could sit down anywhere, any time, and grind out a report. But this habit of writing should be among the habits of any qualified technical person, not as an ideal, but as a minimum qualification.

It is the practice, the building of the habit that is the important thing. Precept alone, instruction in grammar and principles of writing and organization, will not inculcate the habit of writing. Ironically—and sadly—our college people are not taught even grammar; they are not taught the principles of organization. Anyone who has taught college freshman English knows that in a class of twenty-five students he is lucky to have two or three who have a sound foundation in grammar. The pitch these days is "forget grammar!" Sure, forget grammar, ignore it completely if you like—once you know it! Just like you forget algebra when you get to calculus; you manipulate your algebra automatically. And in higher mathematics you may break the rules of algebra, but you do it consciously; you know what rules you are breaking!

Where Do the Colleges Fail?

Our colleges make a stab at teaching technical report writing. Almost every technical college of every university these days has a report writing course somewhere along the line for its engineers and science undergraduates. Almost all graduate students take a course labeled "thesis writing" or some such title. Where do the colleges fail then?

First of all, as has been pointed out, colleges have the almost impossible job of teaching these students to write before they can teach them anything called "technical report writing." Getting an engineering or science degree these days is such a rat race that it is no wonder that little time can be found for that very time-consuming discipline of practicing "technical writing."

But our colleges fall down not only in failure to teach writing, but in failure to teach at least four specific aspects of technical reporting that the technical report writer must know.

1. First of all there is the outrageously important problem of *Who is your reader?* This is a problem of all writing, for all writing is communication, and to communicate you must address yourself religiously to your reader. This addressing yourself to your reader is particularly a problem of technical writing because there are so many possible levels and combination of levels of readers. One of the most aggravating aspects of report writing to both neophyte and old timer is the keeping your reader always in mind. It is not enough that you say what you want to say; to say what you want to say is not at all what you are after in a technical report. Mere accurate reporting is not enough! What you are after is to convey to your reader the precise information and interpretation of your information that you want him to have. That means you must sit down and decide who your reader is going to be. Is he the man doing work very similar to yours, to whom you can speak almost as to your colleagues on your project? Is he the so-called technically well-informed administrator; the man a ways up the line, who is technically knowledgeable, who wants an over-all picture, but doesn't want to get buried in detail? Is he the layman, uninformed in the basic principles as well as the details of your science or technology? A chemist is a layman to an astronomer or to an archeologist.

Just who is my reader and how should I address him (or them!). To keep this question in mind is to have a report half-whipped before you start. Keeping it in mind, you can decide—though it may gripe your scientific soul and is never easy—what your approach shall be; what words you shall or shall not use, and which if you do use you should define; what data to include or not include; what your best organization shall be; what illustrations to use or not to use; what tables, if any,

should be included. Just deciding who your reader will be gets you well on the way to blocking out your report and keeps you in line once you are under way.

2. Tables are a second aspect of report writing that are either not taught at all or are glossed over in teaching technical writing in our colleges. And if there is one single phase of a report that professional technical writers and editors would pick as absorbing the most time it is tables! The difficulty in tables lies in their rigid format necessitating an equally rigid and simple logic. Relationships between the stub entries and the column headings must be clearly thought out. Grouping of items shows grouping of ideas; important items must be easily picked out and differentiated from subordinate items. In compiling a table, the author or man on the project, will often find that much fundamental thinking must be done. It is this thinking that takes the time. If you don't believe that tables require all the brain power that can be poured into them, take a look at the *Bureau of Census Manual of Tabular Presentation.*

3. Next after tables, the greatest amount of time required in putting together a report manuscript is for illustrations. Illustrating a report is not just a matter of slapping together a few graphs and charts and schematics and assorted photographs as you write the report. Illustrations are an integral part of the report, and if you can just slap in a figure, it has no business in the report. You must decide exactly what points you need illustrated. You must decide what type of figure will best illustrate this point. Once the type illustration is decided, you must decide on the details of the figure. If it is a photograph, you must get the shot from the right angle and the right distance. The photograph must show exactly what you want it to show in exactly the detail, proportion, and scale you want it to show. Nothing is harder when dealing with illustrations than to resist the temptation to slip in a figure just for "art and beauty." A technical report is not an advertising brochure.

4. Fourth of the items that are either not touched upon at all or are glossed over in university report writing courses is methods of reproduction. The report on a project reflects the project. The type of reproduction usually depends on the importance of a report, and, therefore, on the importance of the project. And whoever picks up a ditto report will assume that the project wasn't too important, not in relation to a hard-type report with the hard covers, anyway. Just as the report writer must keep his reader in mind as he writes the report, so he must keep his reader in mind as he considers the type of reproduction to give his report. He should know what kind of reproduction his report is going to get and adjust his effort accordingly. If he is writing a report to be reproduced in ditto, he need worry only about the correctness of his facts and the grossest matters of composition, tabular presentation, illustrations, and "getting to" his reader. If his report is to come out in hard type, on glossy paper, between hard covers, then it behoves him to give the report the finest possible combing over. This relation of project to report and the type reproduction to the amount of work to be put into the report is not absolute, of course; in a crush, highly important matters may be rushed into ditto. But, by and large, the report reflects the project; and the method of reproduction is an index of how much work to pour into a report.

The writer must know then what he can do with ditto, with multilith, with direct and photo offset, with hard type. He must know something about printing and commercial art and publishing processes. As a technical man, he is supposed to be literate, and to be literate in an age as much influenced by printed matter as is ours, is to know a little something about the various publishing and reproducing processes. To the degree that the technical report writer does not know the method of reproduction to be used on his report, to that degree he is unsure of what effect his report will have on the reader. And we have been at pains to point out that

his reader must at all times be uppermost in the technical report writer's mind.

Why aren't these four things—at least—taught in our technical schools? The answer is obvious. They are not taught because they are not thought important enough. Management has not got through to our technical schools—to all our schools—how important teaching writing is—specifically, how important is the teaching of technical writing.

Summary

In the press of college work that crowds the science and engineering undergraduate, forcing him nowadays to five years for his undergraduate degree, other aspects of his training are considered more important than writing. Doing and making are considered more important than writing. The feeling is—unspoken of course—that if the writing problem is ignored it will disappear. And by closing our eyes to the problem we give it that much more opportunity to get out of hand.

If a thorough job is to be done in teaching writing, a ten- or fifteen-year discipline is necessary. Writing cannot be taught by precept, only by practice. If we are really concerned to teach people to write decent technical reports, we must change our attitude toward education in writing and institute something of the Spartan regime. As nothing of the kind is in sight in grade school or high school, it is up to the colleges to give at least four or five years of practice in writing, with indoctrination in the techniques and practices of the technical report.

Until our colleges are made to institute rigorous training in writing, technical organizations will have to do what they can to train their own technical writers, doing what they can to make decent writers out of all their technical men. They must be happy if they discover and develop a few, and see to it that those discovered with adequate report-writing skill are utilized for producing the needed reports. It is unlikely that these training courses of a few weeks will uncover—for they cannot produce—sufficient number of men for report writing. Professional technical writers and editors will have to be increasingly relied upon to produce the report manuscripts and to see them into print. Such an outlook is pleasant only to technical writers and editors, who, because of the unhappy situation, find themselves increasingly in demand.

Mathematics—Engineering versus Arts

By HERMAN K. FULMER

Professor of Mathematics, Georgia Institute of Technology

Introduction

Much has been written about mathematics as a tool versus mathematics as a science, about the difference in approach of those interested in *how* as against those interested in *why*. This basic difference, inherent in the purpose of individuals, is also characteristic of many engineering colleges as opposed to arts colleges. It is the intention of this article to give some examples of this cleavage of thought, both as to individuals and institutions.

Illustrations of the Difference in Approach (Tool versus Science)

Consider the difference in approach to find real roots of $f(x) = 0$ where $f(x)$ is not restricted to algebraic functions. In general the solution will be approximate. Both the tool man and the science man approach this problem. Both look up this topic in calculus books and finally agree to try Newton's Method. Now, as is generally known, a rough statement of Newton's Method is that "If $x = c$ is an approximate solution of $f(x) = 0$, then $x = c - f(c)/f'(c)$ is a better solution." This satisfies the tool man, and so he starts on his problem. If he is able to solve it, he thinks well of Newton's Method, asks no further questions. But the science man starts asking questions at once. On what reasoning is Newton's Method based? Does it always work? How can you distinguish exceptional cases? Looking into all this, the science man finally come up with the following refinement on the original rough statement. Remember that the rough statement was that "If $x = c$ is an approximate solution of $f(x) = 0$, than $x = c - f(c)/f'(c)$ is a better solution." The refinement on this may be expressed as follows: "Assume that c is an approximate value of a root of $f(x) = 0$ in an interval between a and b which contains both c and the root. Also assume that $f'(x)$ and $f''(x)$ exist and that neither $f'(x)$ nor $f''(x)$ changes sign in a $a \leqq x \leqq b$. Then, with certain other minor restrictions it follows that $x = c - f(c)/f'(c)$ gives a better approximation than $x = c$." Thus, having satisfied himself on restrictions under which Newton's Method may be safely applied, the science man solves his problem, and he, too, thinks well of Newton's Method.

Consider the difference in approach in another basic problem—the matter of testing a given function for maximum or minimum. Both men look up references on this topic. They find that $f(x)$ has a maximum at $x = c$ if $f'(c) = 0$ and $f''(c)$ is negative; it has a minimum at $x = c$ if $f'(c) = 0$ and $f''(c)$ is positive. The tool man tries this, and it solves his problem. He concludes that it is a good rule, asks no further questions. However, the science man asks questions. Could we have a maximum or minimum without the stated conditions being true? In other words, does the converse hold? He finds that it does not. In fact, the method will not apply to so simple a case as $y = x^4$, even though there is clearly a minimum at $x = 0$. Distrusting so limited a rule, the science man does not use it at all, falls back on the more fundamental test.

Note that in both illustrations the man interested in mathematics as a tool is satisfied if the method works his problem.

The man interested in mathematics as a science is not satisfied if the method simply works his problem—he wants to know all about the method, its history, derivation, and limitations. If the method failed to work another similar problem, the tool man would probably ask what is wrong problem; the science man would ask what is wrong with the method.

Other Differences—Engineering versus Arts

To those of us teaching in technical schools, the department of mathematics in an arts college appears to have a wonderfully easy time of it. In an arts college, so it seems to us, the mathematics department is a law unto itself, enjoys almost complete freedom, neither trespasses nor is trespassed upon. Old courses may be dropped, new courses added, with few shoals in channels to delay the changes. A given course taught by A may be quite a different course when taught by B. Poorly prepared students may be passed on with no kickback in the future. Students elect the popular and interesting courses, for there are many options.

Contrast the above with the setup in the average engineering college. In the engineering college certain courses in mathematics are required for all students. These courses cannot be dropped. Also, these courses are prerequisites for other mathematics courses and for many engineering courses. It is very difficult to add new courses since the engineering curriculum is already overcrowded. It is not necessary that a course be popular or interesting. A comparison in the business world is when the seller has a monopoly of an essential. In passing we should mention here a peculiar dilemma faced by departments of mathematics in technical schools. On the one hand the demands for mathematics in all the sciences continue to increase. On the other hand science departments tend to hoard the time of their students, are unwilling to grant additional time for the study of mathematics. In other words they want mathematics, but they don't want to allot time to learn it.

Summary

We have tried to show a few of the characteristic differences in the status of mathematicians in many engineering colleges as compared with arts colleges. While it is always hazardous to predict the future, it would seem reasonable to suppose that these differences will remain and probably increase. The increasing demand for more mathematicians creates a sort of void which is sure to be filled by those who can use mathematics as a tool rather than those who know mathematics as a science. On the other hand the ancient urge to be curious, to look into the reasons for things, is certain to expand the mathematics horizon, as it has in the past.

The Role of Engineering Mechanics in Engineering Education*

By PAUL F. CHENEA

Professor of Engineering Mechanics, Purdue University

The role of engineering mechanics in engineering education is so broad and so important that I hesitate to speak on this subject in the fear that I will not be able to properly indicate its scope and thereby will underestimate its importance. It is easy to recount and discuss individual contributions of engineering mechanics to the technical education of the engineering student, but I believe that the teachers of engineering mechanics either are unaware of or completely underestimate the scope and power of the teaching vehicle with which they have been entrusted. It is a rare engineering mechanics teacher indeed who makes the most of his opportunity to contribute to the technical and professional growth of his students. I should like to indicate some of these opportunities and responsibilities with emphasis on those that are the most often overlooked and neglected. To form a framework for this discussion I would like to divide the subject matter into four categories, not because these categories are particularly distinct, but because they are convenient for my purposes here. One might entitle these divisions as follows:

1. Undergraduate Service Courses
2. Graduate Service Courses
3. Research
4. Undergraduate and Graduate Education for Research and Development Careers.

This is not their order of importance, but this sequence does offer some continuity to what I want to say.

* Presented at the Annual Meeting of A.S.E.E., Mechanics Division, University of Illinois, June, 1954.

I. *Undergraduate Service Courses*

In terms of numbers of students influenced, the undergraduate service courses offer the greatest opportunity to the teachers in the field. For various reasons we actually make little use of this opportunity, however. These courses in most curricula are the students' first real contact with scientific engineering. They can offer the student his first real glimpse of professional engineering in its highest form, but instead, they more often than not are dull and academic and appear to the student to be only a little related to his concept of the remainder of his professional education. To prove this point I should like to discuss some specific examples.

Consider the matter of being academic. How many teachers of engineering mechanics take the time to find real, practical engineering problems upon which the student can exercise his knowledge of the fundamental laws of mechanics? How many engineering mechanics teachers have actually looked at the contents of the various engineering curricula to see how the student will be expected to use mechanics in his later courses? Very few, I am afraid; other wise we would not be using the same academic examples that were in use forty years ago. Why do we have so many falling bodies that must fall, so many blocks that must slide down planes, so many strings that must be pulled over pulleys and all of this in a sterile environment frequently without atmosphere or friction? You may say that these simple problems are necessary to keep the student from being confused. I venture to say that he would be quite confused in a frie-

tionless world without atmosphere. To be sure, these approximations to physical reality are useful and necessary, but it should never be forgotten that they are approximations and their usefulness should be questioned at frequent intervals and their validity justified. The average student was born into and raised in a real physical world and he expects to practice his engineering in this same environment. It is not any wonder that he becomes disinterested in solving problems concocted on a stranger-than-fiction basis. This condemnation applies to the current textbooks with a few notable exceptions, and perhaps this is the principal "fly in the ointment." A good mechanics teacher should shake off this tendency to live in a dream world and should be at least as realistic about the engineering profession as the average student.

I hesitate to belabor this point further, but there is an additional place where we have missed the boat in this regard. The way to stimulate a student in an engineering mechanics course is to show him how the principles of engineering mechanics will be useful tools in the area of engineering in which he hopes to carve out a career. But what do we do? We proceed as though 75% of the students were going to be structural engineers and the rest of them were going into the machine design field. This may have been true forty years ago, although I doubt it, and it certainly isn't true today. I admit that these tried and true exercises found in most textbooks are good examples of the application of mechanics. But are they the ones that will generate a burning desire to learn mechanics on the part of a student of electrical, chemical, metallurgical, sanitary, or even aeronautical engineering? I don't think so. If one looks into these areas, one discovers ample examples to form a vehicle for the teaching of mechanics. Some of them are new, but most of them are similar to those of structures and machine design, but in a new disguise; and this disguise is important in generating student interest. We should select our exercises with a view towards the present division of enrollment and not tradition.

Another important responsibility of engineering mechanics undergraduate courses is that of unifying the knowledge that the student has acquired to date. All of the subject matter of mathematics, physics, etc., that forms the students' background should be put to work where applicable; indeed, I would stray off the beaten path a little to make it applicable. It is fashionable today to criticize the teachers of mathematics for not giving the engineering students greater competence in this area, but the most serious deficiency in the mathematics program rests squarely on the heads of the engineering educator; namely, they use but a tiny fraction of the mathematics to which the student has been exposed. It is no wonder that a student cannot integrate in his senior year if the last opportunity to use this tool was when he learned this technique as a sophomore. We continually cry for the mathematics teachers to adopt the "fustes with mostes" approach to their courses; then we carefully help the student "forget it." What we need is more mathematics all right, but not in the mathematics courses. We need to apply all that is now taught and on a frequent basis. In this matter mechanics offers a golden opportunity. But how many teachers of mechanics could sit down now and write out a lesson schedule for the first two years of mathematics for the engineering students as it is currently being taught at their particular institution? Not many would get half of the topics, much less the semester in which the student was exposed to topics in question. Here is an area that demands attention by the teachers and textbook-writers in the field. The above argument also applies, but to a lesser degree, to the physics courses.

There is one further point concerning the undergraduate courses that I should like to make. There is much discussion today concerning the liberal education of engineers. The fashionable approach to this problem is to turn the students over

to the liberal arts teachers as a captive audience for a few courses with instructions to "liberalize them." We engineering teachers usually turn our backs on this process as though it were none of our business. Further, we do little by example that would indicate to the student that an engineer should be liberal in his approach to his profession and life. To the student, the teacher is a model of a successful engineer and supposedly embodies and exhibits all the characteristics necessary to be a success in the engineering profession.

If we define a liberally educated man as one who has an open mind and an awareness of the society in which he lives and his part in this society, then what better vehicle exists for the liberalizing of a young man than the study of engineering that made this society possible. There isn't a single facet of modern civilization that does not have engineering as at least one of its supporting pillars. Here in our own hands we have the most obvious vehicle for creating open minded and liberal citizens; yet we insist on sending the students to the custodians of the classics to learn about the civilization which the engineering profession made possible. As an example of how we could take advantage of this opportunity that we have as teachers, we should introduce into our engineering mechanics courses some history of the field and of its founders. This need not be extensive nor dry facts. It should be based upon the real men who formulated the principles we teach, how they effected their times and how they were influenced by the society in which they lived. It should treat them as human beings playing their important role in civilization and not as godlike people without personal problems or life. A few minutes per class of the type of instruction that demonstrates the place of the present subject matter in the world of the past and today will convince the student that his teacher possesses some breadth of knowledge of society and will do much to encourage him to become a liberal-minded engineer.

II. *Graduate Service Courses*

Many engineering mechanics departments offer graduate service courses; that is, courses intended for graduate students not majoring in engineering mechanics. These courses can play an important role in the graduate programs in the professional areas. To do so, however, they must be realistic, up-to-date and closely integrated with the objectives of the professional graduate programs. These courses should be deficiency courses in the sense that they round out and supplement the graduate courses in other areas. To be healthy there should be a continual flow of subject matter out of these courses and into the professional graduate courses. The course time vacated by such a process should be filled with new applications of science to the field or the course diminished in magnitude. Above all, these courses and their subject matter should not become vested interests of the mechanics staff, for if they do, they will tend to compete with professional graduate courses and their usefulness then is questionable.

III. *Research*

The role of research in engineering mechanics departments should be somewhat different from that in the other departments of engineering, in my opinion. It should be close to the heels of pure science and have as its goal the application of more science to engineering. Again it should not, in the main, compete with research in science or in the professional engineering areas but should supplement and stimulate both of them. Consider the following examples. Engineering mechanics should do research in the computer field, not to design and build better computers and thus compete with the electrical engineers and scientists, but primarily to find new ways of using computers to solve more engineering problems efficiently and economically. We should enter the solid state field not to compete with the physicists or the physical metallurgists, but to apply this knowledge to

the everyday engineering use of materials and a better understanding of their properties. The operational analysis field should be invaded to bring its concepts and techniques to bear on the management and operations of engineering. In the latter example we are on almost virgin ground. Another example is that of the human operator. Much more information is needed about the physical capabilities of the human being if we are to better design machines that he can successfully operate. One can name many more new areas of science that need to be exploited by the engineer which are ripe for a bold attack by the workers in engineering mechanics. In addition to the above, of course, we must continue to search for new applications of the principles of classical mechanics and most important of all, encourage the professional engineering departments to do likewise. The guiding spirit of the mechanics research workers should be to supplement other research in science and engineering and to fill in the gaps where they exist.

IV. *Undergraduate and Graduate Curricula for Research and Development*

The nature of the activities in teaching and research enumerated above gives rise to a fourth very important responsibility of the teachers of engineering mechanics. What better atmosphere could exist for the education and growth of a small group of carefully chosen creative students to be the technical leaders of tomorrow's scientific engineering? Certainly, no place in the engineering educational picture can provide a more stimulating environment for nurturing the spark of genius in a gifted student than a well-balanced engineering mechanics department that is continually searching for new applications of science to engineering. It follows, therefore, that a large share of the engineering education of our most precious commodity, gifted young men and women, is a responsibility properly placed on the various engineering mechanics departments. This is a staggering responsibility, indeed, but one for which we are ideally suited. To shirk this responsibility is to refuse to shoulder our most important obligation; yet most engineering mechanics departments have only accepted this responsibility on a gradute level if at all. It is true that much can be done with more mature students on a graduate level but this is the easy part of the job. To make real progress with students of exceptional ability we must find them early and provide educational opportunities commensurate with their abilities throughout the whole span of their education.

A word or two concerning the selection of students for education in engineering mechanics is in order. Some of my more enthusiastic colleagues have advocated that all students who perform well in their freshman engineering year should automatically be placed in an engineering mechanics curricula. Nothing could be more wrong. Highly talented engineering students and highly talented engineers are needed in all walks of engineering. Only a few of the exceptional students who express a desire for careers in engineering research and development should be accepted in this program. A student in a program of this type with less than his enthusiastic approval will become a frustrated student and engineer when his career would have been spectacular in the field of his own choice. On the other hand students of only average creative and scholastic ability should not be encouraged to undertake a program in engineering mechanics. They would serve engineering and themselves best in roles where doing is more important than creative analysis and synthesis in the engineering sciences.

The curriculum on the undergraduate level deserves considerable thought. It must be far broader than the traditional field of engineering mechanics if it is to fulfill the objective of educating engineers for research and development activities. Above all, it should be remembered that the students electing this curricula will play leading roles in pioneering research activities thirty years hence. Conse-

quently the basic sciences should play a dominating part and not the engineering practice or research of today. The successful research leader thirty years from today must necessarily know much more than can be acquired in the most advanced four year, or for that matter, five, six, or eight year program today. Therefor the primary objective should be to generate lifelong scholars who can educate themselves throughout their careers. The formal university education can only provide a firm foundation for their growth. It is redundant to point out that their teachers must be outstanding scholars and authorities in their respective fields or the whole program must fail.

The curriculum must accomplish at least one additional thing; namely, it must generate an engineering point of view. There is a very real danger of graduating scientists instead of engineers from a program of this type. As Dean O'Brien has pointed out, engineering graduates must be eager to solve the problems that need to be solved in the time available. The fact that a solution is needed should provide all the motivation necessary to stimulate them to bring all of the knowledge and skill they possess to bear on the problem. This can be accomplished by using real engineering problems as vehicles for the program and by confronting the students with teachers who have the engineering point of view. The program must reek with real engineering situations mixed carefully with the pure substance of science.

As an example of an undergraduate curriculum which is pointed towards this goal, there is included in the appendix an outline of the engineering sciences program to be inagurated at Purdue University this fall. It is not perfect and undoubtedly will be modified as more experience is gained in this area. The course titles are not exact in all cases as they have occasionally been modified to make them more descriptive of the course content. Readers wishing greater detail should consult the Bulletin of the Schools of Engineering of Purdue University.

No graduate curricula is included as I feel that flexibility is essential in graduate study. Needless to say the graduate courses must be alive and current. Above all, they must stimulate the student to study the literature firsthand and think for himself. There should be guidance, to be sure, but of the provocative kind that creates a keen desire to investigate situations for himself.

Much has been said about theses. I for one do not believe that the usual Master's thesis is very fruitful. In my opinion it absorbs too much time for the benefit derived at a stage of the student's career when his breadth of knowledge still needs widening. A carefully planned project course can give the student a chance to proceed on his own initiative without shortening his Master's degree program by a third or more as is often the case with a thesis program. In fact, the need for a thesis usually grows out of the failure to conduct the graduate courses in the proper fashion. If the graduate courses spoon feed the student, then by all means this deficiency must be made up by a research program which forces the student to think for himself. If, on the other hand, the graduate courses are conducted in a manner that has the class continually searching on their own time for related information and ideas, then a thesis on the Master's level really has little additional to offer. On the doctorate level I believe that the program should be constructed completely around his dissertation and every course, if indeed any are needed, should directly contribute to this goal.

Let me say in conclusion that I believe the teachers in engineering mechanics have a responsibility and an opportunity unequalled in their history. The future of engineering education stands to benefit immeasurably if they accept the challenge.

APPENDIX

An Outline of the Curriculum for Engineering Sciences follows:

(Total credits—155⅓ semester hours)

Freshman Year

(Common to all engineering curricula)

(4) General Chemistry	(4) General Chemistry
(3) Composition	(3) American Books, Essay, Drama, Poetry, or Fiction
(2) Engineering Drawing	(2) Engineering Drawing
(0) Engineering Lectures	(5) Analytic Geometry
(5) Algebra, Trigonometry	(2⅓ to 3) Military Training
(2 to 3) Military Training	(2) Plane Surveying
(⅔) Personal Living	
(2) Welding, Heat Treating and Casting	
(18⅔ to 19⅔)	(18⅓ to 19)

Summer Session

(4) Calculus I

Note: A summer session is not required if the student has completed Calculus I during the Freshman year.

Sophomore Year

(3) Basic Mechanics I	(3) Basic Mechanics II
(1) Experimental Engineering Science I	(4) Mechanics of Solids
(3) Expository Writing	(1) Experimental Engineering Science II
(4) Calculus II	(3) Intermediate Calculus
(3) Elementary Metallurgy	(3) General Thermodynamics I
(3) Principles of Speech	(4) Basic Electrical Circuits and Electronics
(2⅓ to 3) Military Training	(2⅓ to 3) Military Training
(19⅓ to 20)	(20⅓ to 21)

Junior Year

(2) Experimental Engineering Science III	(3) Economics
(3) History of Europe since 1914 or U. S. in World Affairs	(1) Experimental Engineering Science IV
(3) Vector Analysis	(3) Basic Mechanics III
(3) Applied Theory of Complex Functions	(3) Theory of Material Properties
(3) General Thermodynamics II	(5) Ordinary and Partial Differential Equations
(3⅔) Fluid Mechanics	(3) Electromagnetic Theory
(17⅔)	(18)

Senior Year

(3) Projects in Engineering Research, Design and Development I	(4) Projects in Engineering Research Design and Development II
(0) Engineering Inspection Trip	(4) Continuum Mechanics II; Fluid Mechanics and Acoustics
(4) Continuum Mechanics I; Elasticity and Plasticity	(3) Systems Analysis and Synthesis
(3) Nuclear Engineering	(3) Elements of Democracy or International Relations
(3) Numerical Methods in Analysis	(3) Psychology for Engineers
(3) Electronics Techniques for Physical Research	(3) Non-technical Elective
(3) Non-technical Elective	
(19)	(20)

The Case Method of Teaching Mechanics*

By FERDINAND L. SINGER

Associate Professor of Engineering Mechanics, New York University

First let me state that if the title of this paper seems to imply a new and novel method of teaching mechanics, such is far from true. If such an impression was inadvertently created, I apologize for enticing you to be here today. May I start by explaining the choice of the title?

"The Case Method of Teaching Mechanics" describes a technique that has been used at New York University with gratifying success. The method is not startling in its concept and indeed may not even be new to you. It arose out of a growing need for more time to discuss the many topics that we cover in mechanics courses and at the same time retain the class participation needed for successful teaching.

The name was borrowed from the method used in teaching law. In many of those courses, the various points of law are developed in terms of the cases in which they were tried in the courts. Usually quite a few cases are assigned for study and the professor then calls on students at random to discuss any of the assigned cases.

Unfortunately, the cases are usually lengthy and require close study of the fine points of the law and, as a result, many students have time for only a cursory study of them all. In fact, during a recitation on the cases, most students were so busy refreshing their memory of the next case to be discussed that few paid much attention to the case under current discussion. One law professor of my acquaintance eliminated this difficulty by assigning one case to each student, this case being the only one for which the student was responsible and the only one on which he would be graded. Moreover, if that student were absent from the next class, the professor would recite in his stead. Thus the professor succeeded in having all students fairly alert to the class discussion instead of studying the next case.

Unfortunately this method cannot be applied verbatim to classes in mechanics. We rarely assign more than three problems at a time, and if only three particular students were assigned to recite at the next session, the vagaries of human nature would ensure very little active preparation from the rest of the class. Furthermore, the study of law and engineering are different in that while it may be possible to absorb points of law from a class discussion, engineering requires personal experience and participation beyond that of merely listening to an explanation. Nevertheless, the concept used by this law professor was so appealing that I developed a variation that I shall describe in a little while.

But first let me summarize the requirements of effective teaching. These are:

1. The learning and understanding of new principles.
2. Correlation of new with old ideas.
3. Training in orderly and logical analysis.
4. Practice in applying fundamental principles to new situations.
5. Discover student weaknesses and help them to overcome them.

This brings us to the heart of the case method of teaching which is essentially a

* Presented at the Annual Meeting of A.S.E.E., Mechanics Division, University of Illinois, June, 1954.

simple and effective manner of ensuring adequate homework preparation and its discussion. Most of us would agree this is really the keystone of successful teaching. Good textbooks and good lectures only supply the necessary background, but no one can really learn except through the personal experience of trying to apply a principle. This plus the clarification that comes from personal explanation of a topic is what really does the trick.

Let me now present the method and tell you how it is applied. It is possible that it may only be a variation of schemes that you may be using. Certainly, I am sure it can be improved. I hope it will provoke sufficient discussion to indicate such improvement.

The class is divided into three equal groups and it is the responsibility of each group to be thoroughly prepared on one of the three problems assigned. Any member of a group may expect to be called upon to recite on their group's problem but not on the others. Of course it is expected that they work out the other problems of the assignment also, but they know they need not recite on them. The recitation of other groups on the other problems enables them to fill in whatever gaps they may have encountered in trying and preparing the other problems. The essential feature of this method is that it ensures complete preparation by each student of at least one problem for each lesson.

At the start of the lesson, one student from each of the three groups is asked to put his problem on the blackboard and then to explain it. While this is done, the instructor summarizes the salient features of the next assignment, stressing those elements that he knows may cause difficulty. (It should be noted that although the students at the board miss this summary, they do so only about once in every 10 lessons.)

No grades are given for these problem recitations; only a check mark made to keep a record of who has recited. Occasionally a student appears unprepared. He then is required to submit all previous homework for inspection at the next lesson. In all cases when a student is obviously unprepared or when his quiz work is below passing, he is required to submit his homework for inspection at the next lesson. This procedure, together with random calling for a student's work, keeps the instructor informed about the quantity and quality of student work without the necessity for daily collecting and checking it.

Occasionally the student selected pleads that he knows his solution is wrong. This, to me, is even better than a perfect solution, for the chances are that others in the class have encountered the same trouble. Then I and the class have the chance to see where and why the student went astray. The student is then guided by what I hope is adroit questioning to the correct solution.

Examine Student's Presentation

The entire class thereby has the opportunity to examine the student's presentation of method and computational technique. There frequently is a lively discussion of alternative methods and the chance to show better and more accurate as well as faster methods of computation. I believe that one of the most valuable contributions of a recitation, especially where a student is thoroughly prepared and expects to recite under the case method, is the experience gained in speaking on one's feet and explaining as well as defending his presentation.

At this point, I suppose many of you are thinking that there is nothing novel in this procedure—that it is exactly what each of you do in your class recitation. Granted! The essential difference is that usually *any* student may be called upon to recite upon *any* of the assigned problems. Here he is a member of a group responsible for but *one* problem. Consequently, the instructor can reasonably expect a student to be better prepared than usual for that one problem.

In actual practice, the method has worked extremely well. I have been able to keep in close touch with all the students' work while not imposing a severe burden upon any. They like the method and cooperate fully. Examination of their work shows that generally they are up to date in all problem assignments, possibly because those they have trouble with have been fully explained in class.

One additional detail should be mentioned. The three groups are identified as group 1, group 2, and group 3. For the first assignment, the members of group 1 are responsible for the first problem of the assignment, group 2 for the second problem, and group 3 for the third one. However, the order of responsibility for assigned problems is changed with each assignment since the problems usually vary from simple to medium to maximum difficulty, and it would be manifestly unfair to keep one group responsible for only one type of problem difficulty. Therefore, the order of group responsibility changes at each lesson from 1, 2, 3, to 2, 3, 1, to 3, 1, 2, and back to 1, 2, 3.

I am sure that most of us realize that although the basic topics covered in today's courses in mechanics and strength of materials are relatively unchanged, their range of application has been greatly enlarged. Most modern textbooks provide so wide a variety of applications that an instructor who attempts to cover them all, generally has insufficient class time. If the attempt is made, they can only be discussed so briefly that confusion frequently occurs. I believe it to be better pedagogy to stress understanding of fundamental principles so firmly that the student develops confidence in his ability to apply them to any situation.

Since most modern textbooks are written in a clear prose with adequate illustrative problems, it would seem desirable to choose a method of instruction that takes full advantage of them. As I have indicated, this can be done by a limited class discussion or amplification of principles that may not be adequately covered by the text and by lively class discussions of assigned problems by which the basic principle common to all of them can be reemphazied. Incidentally, by forcing closer study of the text upon the student, we are encouraging them to develop study habits they can apply with continuing success after graduation. Most of the class time, especially if the case method of instruction is used, would then be available for class discussion of adequately prepared problems in which to emphasize the basic principle common to all the problems instead of trying to treat each problem as a special case or type.

ANNUAL MEETING—1955

Pennsylvania State University

State College, Pa.

June 20-24, 1955

ECPD Accreditation of "Fringe" Curricula

After due consideration, and after participation by several of its members in the deliberations and Interim Report of the ASEE Committee on Evaluation of Engineering Education, the ECPD Education Committee recommends as follows:

1. That the following curricula be accredited as Major Engineering Curricula: Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, Metallurgical Engineering, and Mining Engineering.

2. That the following curricula be accredited as Cognate Engineering Curricula: Aeronautical Engineering, Architectural Engineering, Agricultural Engineering, Ceramic Engineering, Geological Engineering, Geophysical Engineering, Industrial Engineering, Engineering Mathematics, Engineering Mechanics, Naval Architecture and Marine Engineering, Petroleum Engineering, Engineering Physics, Sanitary Engineering, Textile Engineering.

3. That additional Cognate Curricula be approved by ECPD after specific authorization by ECPD based on recommendations from the Education Committee.

4. That a curriculum in Engineering or in General Engineering be accredited if it meets the criteria for other major or cognate engineering curricula.

5. That any curriculum be recommended for accreditation only when it meets the following criteria in addition to those heretofore adopted by ECPD:

a. At least the equivalent of an academic year of the curriculum shall be devoted to mathematics and basic science about equally divided.

b. For Major Engineering Curricula the equivalent of approximately one academic year shall be devoted to the engineering sciences, including at least six of the following: statics; dynamics; strength of materials; fluid flow; heat flow; thermodynamics; electrical circuits, fields, and electronics; engineering materials; physical metallurgy.

c. For Cognate Engineering Curricula only the equivalent of approximately two-thirds of an academic year need be provided for coverage of the engineering sciences as listed in item 5b, provided that the remaining one-third of this equivalent academic year be devoted to other appropriate applied sciences, or basic sciences in addition to those listed in 5a.

d. Approximately the equivalent of one-half of an academic year shall be devoted to engineering analysis, design and engineering systems.

e. The curriculum shall be designed for an integrated sequential study in the scientific and engineering area. The mathematics and the basic science to be used proficiently in the work in engineering analysis, in the study of engineering systems, and in the preparation for creative design.

f. An appropriate portion of the curriculum shall be devoted to the humanistic and social studies.

6. In any case in which the Education Committee is persuaded that well-considered experimentation in engineering curricula is underway, it shall give sympathetic consideration to departures from the criteria of Sec. 5 and shall make appropriate recommendations to ECPD.

The committee recognizes that these recommendations constitute a departure from past practice in that an approach is made to quantitative criteria as to curriculum content and distribution of time.

However, the committee feels that the principal justification for curriculum designations other than those in the "major" group is to provide engineers who are versed in one or more fields of applied science but who must have an adequate background in the items covered by the criteria outlined to assure that they are in fact qualified for admission to the engineering profession. Curricula of a vocation or technical institute pattern could not qualify.

The committee continues to favor the general policy of ECPD looking toward the minimum number of specially designated curricula, and endorsing whenever practicable the utilization of options in major curricula (as Sanitary option in Civil Engineering) to designate specialization.

ASEE Catalog of Learning Aids

Civil Engineering

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Engineering Mechanics

Mathematics

Prepared by the ASEE Committee on Teaching Aids. Over 5000 teaching aids have been reviewed. The catalog lists 290 aids which are rated by the ASEE reviewing committees as the best available learning aids for engineering education. The catalog summarizes the content of each aid, recommends the course for which it is best adapted, gives details of physical size, equipment necessary, where it can be obtained, cost and other pertinent data.

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American Society for
Engineering Education,
Northwestern University,
Evanston, Illinois

Remuneration Policies of Engineering Colleges in Regard to Research and Consulting

By V. E. NEILLY

Assistant Professor of Electrical Engineering, Pennsylvania State University

Secretary, Engineering College Research Council, 1952–54

For some time the Executive Committee of the Engineering College Research Council has considered making a survey of existing institutional policies and attitudes on research by the faculties of our engineering colleges. A questionnaire covering several aspects of this work was prepared and in December of 1953, this questionnaire was sent to the representatives of each member institution of the Engineering College Research Council. This paper gives a tabulation of the answers received together with some observations by the writer. While some of the questions proved not to be completely clear or were not worded in such a way as to secure compatible answers, considerable information was obtained that should be worth while in a study by any institution or group concerned with academic research policies.

On behalf of the chairman and the executive committee of the Engineering College Research Council, I wish to thank those research and administrative officials who completed the questionnaire. Of the 103 sent out, completed questionnaires were received from 98 institutions. Many letters accompanying the returned questionnaires expressed considerable interest in the subject and in this report. To me, the fact that 98 officials took time from their busy schedules to answer these questions attests to their opinion of the importance of this work. In the letter of transmittal, the chairman assured each institutional representative that his reply would be kept confidential, that no institution would be named, and that the answers would be published only in statistical form. This report will conform to these restrictions.

This questionnaire was divided into five sections headed Consulting Work, Sponsored Research, Administration, General Work Regulations and Work Regulations for Sponsored Research. From three to six questions were asked under each heading with a total of 24 questions. This report will give the exact wording of each question followed by a tabulation of the answers received.

I. Consulting Work

A. Does your institution permit academic staff members to do consulting work for compensation in addition to their institutional salaries?

(98 answers to this question)

Yes—95

No—0

Not during academic year—3

B. If "yes" is any restriction placed on amount?

(96 answers)

Yes—74

No—22

C. If "yes" what is the restriction? $....., % of institutional salary ....., time ....., other (explain) .....

(90 answers, however many institutions gave more than one restriction)

$100 per month—1

Percentage of institutional salary —4

20%—1

25%—1
25 to 30%—1
50%—1
Time—39
1 day per week—28
½ day per week—3
10 hours per week—1
20% of scheduled time—1
25% of scheduled time—2
Unspecified time limitation—4
Must not interfere with other duties—32
Must not compete with practicing engineers—2
Must be creative—1
Must be professional level—8
Must be approved by administrative officials—2
Each case decided on its own merits—1

D. Are there any restrictions placed on who can do consulting work?
(96 answers)
Yes—15
No—81

E. May a staff member do consulting work for extra compensation for his own institution?
(92 answers)
Yes—34
No—41
Only under special circumstances —14
This situation has never arisen—3

II. Sponsored Research

A. Does your institution permit academic staff members to do sponsored research for compensation in addition to their institutional salaries?
(95 answers)
Yes—63
No—23
Only under special circumstances —8
No policy—1

B. If "yes" is any restriction placed on amount?
(62 answers)
Yes—59
No—3

C. If "yes" what is the restriction? $....., % of institutional salary ....., time ....., other (explain) .....
(64 answers, some institutions have more than one restriction)
$300 per month—1
$250 per month—2
$150 per month—1
$125 per month—1
$100 per month—3
20% of institutional salary—5
25% of institutional salary—6
67% of institutional salary—1
33% of institutional salary (summer only)—3
2/9 of institutional salary (summer only)—1
Limited to the equivalent of two months' salary—1
1 day per week—5
10 hours per week—4
20 hours per week—1
6 hours per month—1
20% of scheduled time—2
25% of scheduled time—3
Time limitation (unspecified)—2
Restricted to vacation periods—10
Must not interfere with other duties—6
Permission of administrative officials required—2
Each case considered on its own merits—1
More than one day per week compensated by reduction in teaching load—1
No policy—1

D. If a teaching staff member is released, part or all of his time, for sponsored research with the research agency assuming the responsibility for this portion of his income, may he receive a higher rate of compensation for this portion of his time than he would receive for teaching?
(91 answers)
May receive a higher rate of compensation—29
May not receive a higher rate of compensation—58

May not normally receive a higher rate, but there are some exceptions—4

E. Are there any restrictions placed on who can do sponsored research?
(97 answers)
Yes—11
No—85
No policy—1

III. Administration

A. Who administers your sponsored research contract? Engineering experiment station ....., a separate group like a research foundation or research institute ....., a graduate school ....., regular business office ....., other .....
(97 answers. Some institutions listed more than one administrative agency)
Experiment station (or other integral division of Engineering school)—32
Separate group—29
Graduate school—5
Regular business office—27
Research committee—5
Coordinator or director of research—5
Individual departments—2
Industrial research division—1
Individuals—2
Engineering department—1
Dean of Engineering—1
Other (unspecified)—4

B. If a separate group, is it an integral part of your institution or is it a separate corporation?
(27 answers)
Integral part—13
Separate corporation—14

C. In the case of a separate group, is the salary paid to the research worker directly or through institutional channels?
(21 answers)
Direct—4
Through institutional channels—16
Either direct or through institutional channels—1

IV. General Work Regulations

A. What is your normal work week in hours? For teachers ....., for researchers .....
For teachers (91 answers):
40 hours—25
44 hours—10
15 contact hours—6
No stated policy—23
Twenty-seven other answers varied from a low of "10 to 12 hours" to a high of "40 to 50 hours." As there were only one or two of each different answer, it would be too awkward to attempt to classify them. Considerable confusion was found due to the lack of a definition of an "hour." Some answered simply in "hours," others in "contact hours," "credit hours," "credits," and "lecture hours."
For researchers (89 answers):
40 hours—56
44 hours—11
35 hours—4
37½ hours—2
36 hours—1
39 hours—1
45 hours—1
40 to 44 hours—1
40 to 45 hours—1
No stated policy—11

B. What is your normal work year in months? For teachers ....., for researchers .....
For teachers (97 answers):
9 months—66
10 months—11
11 months—3
12 months—6
9 and 11 months—4
9 and 12 months—4
10 and 12 months—1
9½ months—1
12 months with every third summer off—1

For researchers (94 answers):
9 months—5
10 months—1
11 months—3 *
12 months—79 *
9 or 12 months—2
10 or 12 months—3
No stated policy—1

C. What is your vacation allowance? For teachers ....., for researchers .....

The answers to this question were so varied and in so many forms that it was not considered feasible to classify them. For teachers, most gave a nine-month schedule (see B above) and listed three months' vacation. Some, however, listed a vacation schedule during the academic year. For researchers, the majority listed one month for those on a 12-month work year; however others listed two weeks, three weeks, and in many cases the vacation length depended on length of service.

D. Are all hours in excess of those mentioned above the individuals' own time or are restrictions imposed on how they may be employed?
(83 answers)
Individuals' own time—62
Restrictions are imposed—21

E1. Can annual leave (vacation time) be accumulated from one year to another? ....., for how many years? .....
(89 answers)
Leave may be accumulated—14
For 2 years—8 †
For 3 years—2
For 1½ years—1
For 7 years—1
Time limitation not given—2
Leave may not be accumulated—70
May be accumulated only in exceptional cases—5

E2. If the individual elects to work, is he paid double for his leave time?
(67 answers)
Yes—4
No—60
Extra compensation paid, but not double—2
Situation has never come up—1

F. If an individual's employment is terminated through no fault of his own, is his final check for time actually worked; or is he paid, in addition, for any leave time he has accumulated?
(86 answers)
Time actually worked—11
Accumulated leave time—70
At the option of the administration—4
No policy—1

V. Work Regulation for Sponsored Research

(The following questions pertain only to academic staff members employed on sponsored research on either a full-time or part-time basis. If they are the same as for teaching employees, please so indicate after your answer.)

A. What is your policy on sick leave?
(78 answers)
1 day per month—4
1¼ days per month—3
1½ days per month—1
2½ days per month—1
10 days per year—2
13 days per year—1
14 days per year—1
2 weeks per year—6
Up to 6 weeks—1

* Twenty-six reported 11 months; however 23 of these also listed one month's vacations. These were considered as 12-months' schedules.

† Three of these were listed as one year; however, from the wording of the question, this was taken to mean one additional year and included in the 2-year classification.

Up to 3 months—1
Up to 6 months—1
Full pay for reasonable absences —12
Unlimited—1
Practically unlimited—1
Rest of month plus one month—1
Depends on length of service—2
Policy too complex to classify—1
Full pay for 6 months; half pay thereafter—1
Till end of semester—1
Up to one year full pay less salary paid to substitute if needed—1
Each case determined on its own merits—35
Same as for teachers—46

B. What is your policy on retirement pay?

(75 answers)

State employee's retirement plan —11
Teacher's Insurance and Annuity Association—16
Social Security—3
T.I.A.A. plus Social Security—11
Institution sponsored plan—15
Institution plan plus Social Security—2
State teacher's plan—3
State teacher's plan plus Social Security—1
State employee's plan plus Social Security—2
Institution plan and/or T.I.A.A.—1
Institution plan and state plan—1
1½% of maximum salary per year's service—1
No policy—8
Same as for teachers—38

C. What is your policy on hospitalization and health insurance?

(85 answers)

State employee's plan—1
State teacher's plan—1
Optional group policies available —39
Compulsory group policies—2
Group policies (optional or compulsory not stated)—28
Institution sponsored plan—3
No policy—11
Same as for teachers—32

D. Do you have Workman's Compensation Insurance?

(93 answers)

Yes—68
No—24
Only when required by Government contract—1
Same as for teachers—20

E. For how long after the death of an employee do you pay his salary?

(87 answers)

Pay terminates on day of death—30
Continues until end of month—14
One month—8
Until day of death plus accrued leave time—4
One month plus accrued leave time —1
Two months—1
One month per year's service—1
Varies with length of service—3
Rest of the semester—1
Rest of the fiscal year—1
If single, till end of month; if married, each case considered on its own merits—1
Each case considered on its own merits—22
Same as for teachers—20

This report is intended only to present the results of the survey; the reader may make his own conclusions and compare the policies of his institution with the data presented here. It should be noted that the survey included colleges with large enrollments of engineering students and those with small enrollments; state supported and proprietary institutions; some with multi-million dollar research budgets and others with only a very few thousands. In view of the many variations, it is not surprising that so many different answers are given to questions of policy; it is perhaps more unexpected to find many areas of agreement.

Education-Industry Cooperation for Increasing Planned Faculty Employment in Industry*

By GEORGE K. DREHER

Steel Founders' Society of America

Purpose

It is the purpose of this paper to present evidence which would tend to encourage industry in various sections of the country to make increasing use of the faculties of our engineering colleges. The end result of such encouragement would reside in the improved understanding by faculty members of industrial operation, thereby making their teaching tasks more applicable to the actual needs of industry and, even more than that, to bring into action the vast amount of engineering and scientific knowledge possessed by the higher level faculty members of our engineering colleges.

Method

In so doing, we have endeavored to determine the following by means of a survey addressed to educators, selected industry personnel and engineering college administrators. The specific objectives of this survey are best defined by the following list:

a) The scope of faculty employment by industry.
b) The purpose of such employment.
c) The time during the year when such employment occurs.
d) To identify benefits to faculty and industry alike.
e) To identify secondary benefits to students and society in general.
f) To recommend a general policy to foster and guide a possible program.

Reservations

Certain reservations must be kept in mind. The survey was restricted to a relatively small number of schools, and the same can be said for administrators and industry personnel alike. It is our hope that the material presented hereafter will represent a sampling which will be sufficient to identify the general trend in either the employment of faculty members by industry or the role of individual companies and industries as clients of the engineering faculty. By no stretch of the imagination can this paper be regarded as a scientific analysis. It is, however, of sufficient value to be an encouragement and an example to all concerned.

Faculty Questionnaire

In the questionnaire addressed to faculty members, several questions were asked which are analyzed as follows:

One hundred seventy-eight members replied, which break down to ten per cent in the Instructor group, thirty-one per cent assistant professors, twenty-four per cent Associate professors, and thirty-five per cent full professors. Of those replying, only nine did not have prior employment in industry in any form.

Thirty-nine per cent of those replying engaged in summertime activity only; five per cent functioned with industry during leave of absence; thirteen per cent were on part-time employment; thirty-

* Presented by John Gammell, Allis-Chalmers Manufacturing Co., at the Meeting of Institutional Representatives, ECAC, University of Illinois, June 18, 1954.

eight per cent acted as consultants on a continuous basis; and five per cent did not answer the question.

In answer to the question as to the reason for such industrial service, thirty-five per cent replied that they had hoped to gain experience in their particular field; sixteen per cent identified their service as a means of earning money; six per cent functioned as teachers in industry. Another six per cent acted as research aids; five per cent worked as analysts; twenty-one per cent were assigned to a specific problem; six per cent functioned as project directors; three per cent were employed in the research field directing others; and two per cent attended short-term seminars conducted by various firms.

Remuneration for these services found that twenty-two per cent of those employed by industry were paid on an hourly basis, with thirty-four per cent on salary. Twenty-one per cent were paid on a per diem rate, and fourteen per cent functioned under contract arrangement. Nine per cent did not answer the question. The per diem and contract groups had their expenses paid as well, and the same is true for a smaller proportion of the salary contingent.

These men reported to various individuals within their respective corporations during the time of their employment or service. Only one per cent reported to foremen, and another four per cent to superintendents. We believe that this is rather significant, as the balance of the men so employed made their reports to the higher echelon in the business world. We tabulate these as follows:

To Department Head	18%
To Plant Manager	3%
To Manufacturing Mgr.	2%
To General Manager	7%
To Project Engineer	13%
To Chief Engineer	18%
To Research Director	12%
To Vice President	9%
To President	13%

Reports are made in a variety of ways. The survey shows that twenty-four per cent of them were made verbally to their superiors, and forty-one per cent were in written form. Thirteen per cent were illustrated in various manners, and seventeen per cent did most of their reporting by means of drawings. Four per cent used models to present their results, and only one per cent in patents. It must be borne in mind, however, that much of the work done by others perhaps led to, or was a part of, research and development which could, and probably did, lead to a greater number of patents over a longer period of time.

The policy covering patents granted varied, but for the most part they belonged to the company.

Several other points grew out of this particular question. In some cases, the same policy existed as for other employees. In others, the rights were granted to the government. A few companies took the patent and shared the royalty with the faculty member so employed.

In one instance, the patent was granted in the name of the faculty member, but the rights were held by the company. In others, patents were signed over by virtue of prior contract. Four responses indicated that the faculty member received a bonus or shared in the benefits of the patent.

Appendix "A" lists the colleges whose faculties have responded to this questionnaire. Appendix "B" shows the nature of the industries and professions employing or engaging faculty members, and Appendix "C" lists the companies for whom they served.

College Administrator Questionnaire

Fourteen engineering college administrators answered a parallel questionnaire about the policies and activities of their own colleges. Running throughout these replies was the general statement that

most relationships of their faculties with industry were okay if they did not interfere with school obligations, such as committee assignments or research assigned by school authorities.

The majority of these schools also reported that over 50% of their faculty engaged in some sort of paid summer employment or professional work. The reverse was true of the college year activities, where only two schools indicated that over 50% of their faculty engaged in some work. The remainder reported less than half who had part-time or consulting activity during the regular school months.

The regulations covering such work quite naturally were very limited, as far as the summer activity is concerned, except where the faculty member was assigned to summer school or administrative work during that period. One school stated that they insisted that their faculty men have at least one month's vacation.

Written requests and subsequent permission were needed in the majority of cases for leaves of absence. Most of the schools have a sabbatic leave granted for one term after a specified length of service; a few indicated that no regulations had been set up, and each case was considered on its merits. These leaves are restricted, depending on school policy, to anywhere from six months to one year maximum time.

Part-time school year activities were divided up between written requests and permission with an open policy, as long as it did not interfere with school obligations. Strangely enough, an equal number stated that no firm regulations existed.

Essentially the same general practice applied as far as consulting and professional services were concerned, although in a greater number of cases more freedom was allowed the faculty member, as long as it did not interfere. Two of the colleges reporting stated that only a specified number of hours per week were permissible.

Where on-campus services were required which involved the use of laboratories and equipment, considerable variation was recorded. It appears that, where the faculty member is assigned a research project by the school, his teaching load is correspondingly reduced to permit such activity. At other schools, any on-campus activity is a matter of contract between the college and the particular company or industry involved. At others, a fee is fixed for the project in mind, which the faculty member must include as a part of his fee to the client. It is also evident that considerable discretion as to what this overhead and laboratory fee should be resides in the heads of the departments in many institutions. Other schools apply fixed overheads up to as high as 40% of the direct time involved, and others have a flat 33⅓% charge of the fee earned by the consultant.

Publication rights for college-sponsored work are generally given to the individual. Two schools stated that it was the property of the school in all cases. It is also evident that the school expected such publications to bear the name of the university and to give due credit to the school and other faculty members for the assistance rendered.

Patents presented a rather mixed pattern. If the project was not subsidized or directed by the college, the patent could belong to the individual. Where the company has sponsored the research, the company gets the patent, but the college reserves the right to use the same in their own operation. One college indicated that, if college facilities were used, the resulting patent belonged to the school; in others, the royalties were to be divided among the individual, the school and the company.

The results of this section of the survey would indicate that no definite pattern

seems to exist, with the possible exception of the statement made at the beginning—namely, that on-campus and off-campus activities were permissible if they did not interfere with their teaching duties.

Industry Questionnaire

Seventeen industries responded to another questionnaire concerning their use of faculty talent, both as employees as well as for professional services.

Some of the general scientific and engineering fields identified by them are rather unusual. In addition to the regular engineering and scientific types of service, these firms also indicated that psychology, physiology and pure mechanics were important to them. Other fields included automatic controls, chemistry and metallurgy, research, development, design, power generation, general construction and aircraft.

For the most part, these firms specified the employment of professors, assistant professors, associate professors and instructors in that sequence of relative importance. Strangely enough, this employment was about one-third during the summer, and the other two-thirds on a part-time or consulting basis during the whole year.

These companies also indicated that most of these men were engaged for work on specific problems, or as an analyst or research aid. Lesser numbers were employed purely as an opportunity for the man to gain experience, and a few were employed as teachers for plant programs.

Remuneration was generally on a salary basis, although contract and per diem were identified as a frequent mechanism for this purpose.

These companies also specified that for the most part these faculty members reported to Department heads, followed closely by the Chief Engineer or the Research Director. Lesser numbers reported to the President, Vice President, or the Superintendent. Only occasional cases where Manufacturing Manager, General Manager, or the Plant Manager came into the picture were noted.

Reports were equally divided between verbal and written, and in about two-thirds of the cases all patent rights are the property of the company. In the balance of the cases, some division or bonus arrangement was in effect.

Appendix "D" lists the names of the companies replying to the questionnaire.

Conclusions

We believe that this paper, which very briefly presents the wealth of material contained in the survey replies, does accomplish its initial purpose—namely, to serve as an encouragement and an example to both industries and colleges, and faculty members as well. It not only applies to summer employment, but even more strongly (as the survey results show) to the year-round use of the scientific and engineering ability of faculty members as consultants, analysts and research men for a wide variety of industries.

At the moment, industry is using faculty members primarily for the last-mentioned purposes. There is some evidence that summer-time employment for instructors, and even for professors, is being conducted as a means of acquainting these men with developments in industry and making them aware of the problems which the students will encounter as they graduate from engineering school.

It is evident from the survey, too, that considerable benefit must be attained through the use of this talent by those firms engaging their services. This factor alone should encourage industries in other parts of the country, particularly in the developing south and west, to avail themselves of the abilities within their territory. The wide assortment of indus-

trial activity identified in Appendix "B" leaves almost no loophole as far as industrial coverage is concerned.

Some negative conclusions are also evident in that the policies in regard to patents in industry, as well as on college campuses, vary from the extreme of being completely open to very rigid and thoroughly controlled assignments.

Policies concerning faculty employment have an equally wide-spread pattern within the universities. Some schools have developed very stringent policies on this matter, and others again are completely open or subject to individual consideration.

About the only firm policy that might grow out of the survey, as far as the universities are concerned, is that generally the faculty is permitted to engage in consulting and other outside activity as long as it does not interfere with their teaching load, assignments to committees, and other campus duties by the university administrators, or assignments to direct research work where contracts for same are written with the university rather than with the individual.

The only firm conclusion from the industry questionnaire seemed to reside in the fact that many firms are making extensive use of the scientific and engineering talent possessed by the faculty members. The manner in which this talent is used, paid, and integrated into the company's activity does not seem to develop into a definite pattern at this time.

We must state also that considerable material is contained in the survey replies which has not been incorporated into this paper. We believe that these replies offer material for further development and discussion, and we do recommend that further consideration be given them in future meetings of the Relations With Industry Division.

We are not prepared at this time to suggest that perhaps policies for both industry, as well as colleges, could logically be formed or, if done, that such would be of any concrete value. It is possible, however, that some over-all recommendations could be made. It seems logical that industries will seek out those engineering colleges whose policies are most appropriate and adapt themselves more thoroughly to the operations of the given company. We believe this would be particularly true of the medium to small firms who would shy away from rigid college policies and contracts and would tend to seek out more flexible arrangements at some other university. In other words, it is possible to become too strict in the administration of this faculty employment by industry program on both the industry and college side.

It is hoped that this paper can serve as an eye-opener to some industrial firms and thereby help spread this particular phase of college-industry activity.

APPENDIX "A"

Engineering Colleges Represented in This Survey

University of Alabama
University of California—Los Angeles
Carnegie Tech
Case Institute of Technology
University of Cincinnati
Cornell University
University of Delaware
University of Detroit
State University of Iowa
Lafayette College
Louisiana State University
Michigan State College
Missouri School of Mines
University of Missouri
Northwestern University
Pennsylvania State College
Purdue University
University of Texas
Virginia Polytechnic Institute
University of Wisconsin

APPENDIX "B"

Nature of Industries and Professions Served by Responding Faculty Members

AEC Research
Air Conditioning and Heating
Aircraft
Architectural
Automotive
Ceramic
Chemical
Clothing
Coal
Construction
Consultant
Design
Diesel
Electrical
Electronics
Engineering, Civil
Engineering, General
Engineering Research
Farm Equipment
Foundry
Geophysical
Heating and Ventilating
Heat Treatment
Hydraulic Eng.
Industries with Trade Waste Problems
Instructor
Insurance Companies
Legal
Machine Design
Machine Tools
Magnesium Producer
Management Consultant
Manufacturing
Metals
Minerals
Naval Ordnance
Ordnance
Paper Industry
Petrochemical
Petroleum and Oil
Pharmaceutical
Plastics
Powder Metallurgy
Power
Power Plant
Precision Casting
Printing
Production
Public Utilities
Railroads
Refrigeration
Research and Design
Research (Only)
Shipyard
Steel
Tool
U. S. Govt.
Utility
Water Treatment
Wood Conversion
Writing in Business

APPENDIX "C"

Companies Reported by Faculty Members as Their Employers or Clients

A C Spark Plug
A.E.C.
Am. Bridge Div. of U. S. Steel
Am. Flexible Coupling Co.
Anaconda
F. N. Arbaugh Mfg. Co.
Babcock & Wilcox Boiler Co.
Babcock & Wilson Co.
Bell Labs.
Bethlehem Steel
Biochemical Research Foundation
Black & Veatch Co.
Blue Ridge Overall Co.
Boeing Airplane Co.
Bristol Laboratories, Inc.
Brown & Sharpe
Burlington Instrument Co.
Chance Vought Aircraft
Chicago Pump Co.
Chippewa Flambeau Improvement Co.
Chrysler Corporation
Cleveland Electric Illuminating Co.
Consumer Power Co.
Curtiss-Wright
Cutler Hammer, Inc.
John Deere Plow Co.
Detroit Edison Co.
City of Detroit Lakes, Minn.
Douglas Aircraft
Dow Chemical Co.
E. I. duPont & Co.
City of East Lansing

Eixie Pine Products
Ethyl Corporation
Fiberglass
Foote Mineral Co.
Foster Eng. Co.
G.M. Foster Co.
General Development Co.
General Electric
General Metals Powder Co.
General Motors
Govt. Research Lab.
Grede Foundries
Haller Raymond & Brown, Inc.
Harvard Underwater Sand Lab.
Haynes Stellite Co.
Hydraulic Press
IBM
Jackson & Church
Jackson Industries, Inc.
Kaydon Eng. Corp.
Kish Engineering Corp.
Knapper-Tibbetts-Abbott Engr. Co.
Kohler Co.
Kold-Hold Mfg. Co.
Liverman & Samulson Architects
Lockheed Aircraft
Maxwell Bridge Co.
Missouri Highway Dept.
National Iron Co.
National Lead Co.
Northwestern R. R. Co.
Oak Ridge Lab.
Ohio Malleable
Owens-Corning Fiberglass
Penna. Power & Light Co.
Phila. Electric Co.
Pure Oil Co.
RCA
Reo Motors
Rocky Mountain Hydraulic Lab.
Russell & Axon Consulting Engrs.
Rust Engineering
Sears Roebuck
Geo. G. Sharp, N.A.
Slinger Foundry
Eberle M. Smith Assoc.
S & S Machinery
Standard Oil
Oliver M. Stone, Architect
Texas Foundries
Textile Machinery Works
Tipton Electric & Water Co.
TVA
Union Sulphur Co.
U.S. Air Corp.
U.S. Bureau of Mines
U.S. Bureau of Reclamation
U.S. Engineer Corp.
U.S. Maritime Service
U.S. Naval Gun Factory
U.S. Navy Electronics Lab
U.S. Navy Underwater Sand Lab
U.S. Steel
The Western Company
Western Electric
Westinghouse Electric
York Corporation

APPENDIX "D"

Companies Replying to Questionnaire

Allis-Chalmers Mfg. Co.
American Tel. & Tel. Co.
Bell Telephone Laboratories, Inc.
Boeing Airplane Company
Caterpillar Tractor Co.
Curtiss-Wright Corp.
Detroit Edison Co.
E. I. duPont
Eastman Kodak Company
General Electric Co.
International Harvester Co.
International Nickel Co., Inc.
Minneapolis-Honeywell Reg. Co.
Minnesota Mining & Mfg. Co.
Monsanto Chemical Company
Research Laboratories Div.
of General Motors Corp.
Standard Oil Co., Ohio
Westinghouse Electric Corp.
Anonymous

Engineers Joint Council

For the first time in its history, Engineers Joint Council, composed of eight major engineering societies with a total membership of 170,000, will hold a General Assembly and a banquet. A day-long program of discussions of subjects important to the engineering profession will take place Jan. 21, 1955, in the Hotel Statler, New York City. While a broad variety of topics will be taken up by committees and speakers, the basic theme will be the increase of unity in the engineering profession. The comprehensive proceedings will include addresses at luncheon and dinner by nationally known figures.

Discussions will deal with the problem of engineering manpower shortage, employment conditions as they affect engineers, the national water policy which has occupied the Council's attention for several years, activities in specialized areas of engineering such as in the industrial and peacetime phases of nuclear development, and finally, the future usefulness of EJC to affiliate and associate societies.

Thorndike Saville, Dean of Engineering at New York University, is President of the Council, which will install new officers the evening of Jan. 21

Objectives of Engineers Joint Council include advancement of the general welfare of mankind through the available resources and creative ability of the engineering profession; cooperation of the branches of the profession; advancement of the science and profession of engineering; development of sound public policies in national and international affairs wherein the profession can be helpful through the services of the members of the profession.

To achieve these objectives, the Council acts as an advisory and coordinating agency to seek and study matters of mutual interest to the constituent societies in instances in which these societies desire such joint representation; it administers, on behalf of the engineering profession, activities authorized by a majority of the constituent societies.

Engineers Joint Council operates through twenty-three committees composed of eminent engineers who volunteer their services through their own Society. The activities of these committees are coordinated by the EJC Board of Directors, composed of members of the Boards of the Constituent Societies.

EJC's first General Assembly will close with a banquet to be addressed by Donald A. Quarles, Assistant Secretary of Defense for Research and Development and past president of AIEE.

Minutes of Executive Board*

A meeting of the Executive Board of the ASEE was held in the Hotel Alms in Cincinnati, Ohio on Wednesday, October 27, 1954 at 8:30 A.M. Those present included: N. W. Dougherty, *President*; W. L. Everitt, L. J. Lassalle, B. R. Teare, Jr., and H. K. Work, *Vice Presidents*; G. W. Farnham, *Treasurer*; A. B. Bronwell, *Secretary*; C. E. Watson, *Assistant Secretary*; and M. Strohm.

Report of the Secretary

The Secretary reported on the possibility of his being invited to take the Presidency at Worcester Polytechnic Institute beginning February 1. The Executive Board recommended that a letter be sent to the deans of engineering colleges asking for suggestions for a successor as Secretary of the Society. The Board will meet on November 15 in Washington to narrow down the field of selection and establish a procedure for the eventual choice of Secretary. It was recommended that the matter of location of the ASEE headquarters office be deferred until the new Secretary is found.

The Secretary stated that he would work with the new Secretary throughout the months ahead in effecting a smooth transition and will assist him in every way possible at the Annual Meeting. The commencement activities at WPI terminate on Sunday prior to the Annual Meeting and it will therefore not be possible for him to be present until Monday at the beginning of the Annual Meeting.

Report of the Treasurer

The quarterly report of the Treasurer was presented and accepted. The dues income is approximately $3000 ahead of last year's income for the corresponding period, indicating a probable increase of about $7000 for the year resulting from the change in dues status. The expense items are in line with those of the previous year.

The Treasurer reported that $25,000 of the Society funds had been invested in New York, Chicago and Evanston banks and that $15,000 had been invested in Series K bonds. These funds had been previously lying idle in the checking account. A portion of these funds has been collected from outside agencies and is earmarked for special projects which the Society has in progress.

The Executive Board voted to waive the institutional dues of Northwestern University in view of the space and facilities which are provided for the headquarters office.

Summer Institute Proposal

This item is summarized in the Minutes of the General Council Meeting.

Graduate Study Proposal

A preliminary report of the ad hoc Graduate Committee, appointed to study the possibility of undertaking a comprehensive investigation of the curricular goals and objectives in graduate study, was presented for discussion. The ad hoc Committee felt that the Manual on Graduate Study prepared by a Committee under the chairmanship of Dean Grinter several years ago, provides effective coverage of some of the general policies of graduate study. However, the Committee felt that it would be desirable to conduct studies on specific problems in graduate education. The Committee has not as yet formulated a specific plan as to how such studies should proceed.

Several of the Executive Board members expressed the opinion that a thorough and objective study which would not regard the traditions of the past as

being inviolable, but rather which would challenge some of these traditions would be highly desirable.

Teaching Aids Bulletin

This item is summarized in the minutes of the General Council Meeting.

Evaluation of Engineering Education

The Secretary reviewed the financial status of the Committee, stating that the fund for this study had a balance of less than $5000. Additional financial support seems possible from several different sources.

Publication Policy

The Secretary pointed out that the various Division publications of the Society are providing a vital service in bringing to members of the Society information which could be of direct service to them in their teaching work. He raised the question of whether or not the Society should provide financial assistance to make it possible for the Divisions to expand their publications. The alternative would be to publish more papers of direct value to the teacher in the classroom in the JOURNAL OF ENGINEERING EDUCATION. The latter procedure would get a wider audience, but would be more costly. In general, the *Journal* has tried to carry articles of interest to the major Divisions of the Society, although articles of a highly specialized character have usually been avoided because of limited interest.

It was pointed out that the section entitled "Teaching Tips" in the *Journal* includes papers helpful to teachers. The Board members expressed the opinion that an attempt should be made to strengthen the JOURNAL OF ENGINEERING EDUCATION by including more papers of direct value to the teacher in the classroom.

ASEE Branch at Clarkson College

The application for a Branch of ASEE at Clarkson College of Technology was unanimously approved by the Board.

International Science Foundation

The ASEE Executive Board voted to decline the invitation of the International Science Foundation to become a member. This organization is attempting to set up centers throughout the country for scientists and engineers who visit this country from foreign countries. The Board believed that this service is already being provided by the U.S. State Department and by engineering colleges and other organizations.

Annual Meeting

The Secretary stated that the Local Committee at Pennsylvania State University has been organized and is effectively planning ahead on the Annual Meeting. A meeting of the Committee on the Annual Meeting was scheduled for Friday morning following the Executive Board meeting.

Headquarters office will mail out to the Divisions and Committees of the Society within two weeks a tentative schedule for the Annual Meeting for this year.

A letter from Mr. Gammell, past Chairman of the Division of Relations with Industry, supporting the recommendation of Dean Downie-Smith to the effect that the Society hold a principal meeting on the general subject on "How Does the United States Measure up to the Rest of the World in Scientific-Technological Education" was discussed. Dr. Work stated that ECRC would like to consider a joint meeting with the Relations with Industry Division dealing with this subject.

Summer Schools

The Executive Board voted to approve tentatively the request of the English Division for a Summer School, but urged that the Division prepare an outline and a budget as soon as possible.

A Summer School in Chemical Engineering was proposed last spring, but no specific outline or budget has been received. The Secretary will again contact the Chairman of the Division in this regard.

Section Business

Vice President Teare reported that the Upper New York Section would like to have the University of Toronto affiliated with its Section. The Board voted approval, providing that this meets with the wishes of the members in Toronto.

The question was raised as to whether or not the Section Manual, which was prepared by Dr. Armsby several years ago, should not be printed and distributed to Sections to be used as a guide in the operation of their Section meetings. This manual supplies helpful information on the operation of Section meetings. It was recommended that copies of the manual be sent to the Sections with the understanding that this is merely suggested material.

Questionnaire on Nuclear Science Education

A request to have ASEE send out under its sponsorship a questionnaire to get information on courses offered in nuclear science was discussed. The Executive Board believed that the questionnaire might be sent out by the ASEE Committee on Atomic Energy Education if they deem it advisable, but that it should not be sent out by ASEE Headquarters, since this would establish a precedent whereby ASEE might feel obligated to send out similar questionnaires in other educational areas. The Board believed that the burden of questionnaires raises very difficult problems and in general should be minimized, although there are certain areas where information is highly desirable.

Honorary Membership

The Committee on Honorary Membership has asked the Executive Board for instructions on several matters relating to the qualifications of individuals for Honorary Membership in ASEE. The Executive Board suggested that the Committee prepare its own recommendations for consideration by the Board. One of the principal problems is whether or not a person to be eligible for Honorary Membership should have had active participation in ASEE. It is conceivable that the Society might want to confer Honorary Membership on some outstanding individual who might not even be a member of the Society. The Executive Board felt that membership in ASEE should be a prerequisite and that responsible participation in the Society should be given a great deal of weight, if not be made a requirement of eligibility.

The Next Executive Board Meeting

The next Executive Board meeting will be held at the time of the Land Grant College Association meeting on Monday morning, November 15.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

Minutes of the General Council Meeting*

A meeting of the General Council of the American Society for Engineering Education was held on October 27, 1954 at 6:30 P.M. at the Hotel Alms in Cincinnati, Ohio. Those present included: N. W. Dougherty, *President*; W. L. Everitt, L. J. Lassalle, B. R. Teare, H. K. Work, *Vice Presidents*; A. B. Bronwell, *Secretary*; G. W. Farnham, *Treasurer*; C. A. Brown, W. L. Collins, R. H. Driftmier, R. F. Eisenberg, L. E. Grinter, F. F. Groseclose, K. L. Holderman, H. K. Justice, G. A. Marston, H. C. Messinger, R. S. Paffenbarger, N. A. Parker, H. L. Rodes, L. A. Rose, T. Saville, R. H. Schoonover, R. J. Seeger, P. E. Soneson, L. E. Stout, N. D. Thomas, R. W. Van Houten, R. E. Vivian, K. F. Wendt, W. R. Woolrich; F. M. Dawson, C. W. Muhlenbruch, J. C. Reed, (invited guests); M. E. Strohm.

Report of the Secretary

The Secretary reported that the planning for the Annual Meeting was underway and that the local committee at Pennsylvania State University has been organized and is making substantial progress. This will be the centennial year of Pennsylvania State University, and the Annual Meeting of ASEE will be one of the highlights of the activities of the University. The Executive Board has recommended that there be three General Sessions, scheduled for Tuesday, Wednesday and Thursday mornings. One of these will be a General Session of the Society, which will feature a welcoming address, the ASEE President's address, a program dealing with the progress of the humanistic-social research project, and a discussion of the final report on Evaluation of Engineering Education. One of the General Sessions will deal with the subject "Research and Engineering Education." The other General Session, sponsored by ECAC, will deal with some subject of widespread interest to the Society membership at large.

A General Session will also be held on Monday afternoon at which time there will be reports on various principal projects of the Society. Conferences of Divisions and Committees will be scheduled concurrently with the Monday afternoon General Session.

The Secretary stated that the Divisions of the Society had been urged to hold joint meetings wherever possible.

Report of the Treasurer

The Treasurer reported on the investment of Society funds. This item is summarized in the minutes of the Executive Board meeting.

Summer Institutes—1954

Vice President Teare reported on the Summer Institute on Solid State Physics in Engineering Education which was held jointly by the University of Illinois and Carnegie Institute. Approximately 120 people attended the Carnegie conference. This was highly successful and evoked widespread discussion on educational aspects of this rapidly developing field, particularly in the possibility of getting a more scientific basis for courses in materials. The proceedings of this conference will be published in book form by John Wiley and Sons.

The Secretary reported on the Summer Institute on Nuclear Science in Engineering Education, sponsored jointly by Columbia University and Northwestern University. He stated that the conference was attended by 110 people. This conference agreed with the Carnegie conference in urging that courses in modern physics be offered either as elective or re-

quired courses in the engineering curricula. It also made certain recommendations for treatment of nuclear science and nuclear engineering material. A report of this conference will be published in the *Journal*. The proceedings of the conference will be published either in book form or as a part of the JOURNAL OF ENGINEERING EDUCATION, subsidized by funds available for the conference. The Society owes a deep debt of gratitude to the National Science Foundation for the financial support which it provided for these two Summer Institutes. The great success of these two Summer Institutes has pointed to a new kind of ASEE operation in exploring frontier areas for educational purposes.

Proposals for Future Summer Institutes and Conferences

Dr. Seeger, Chairman of the ASEE Physics Division, presented the recommendations of a Sub-Committee consisting of G. G. Brown, A. B. Bronwell and himself, relating to Summer Institutes for the coming year. Four specific proposals were presented. One of these provides for a Summer Institute in Thermodynamics to be sponsored jointly by Purdue University and Pennsylvania State University. This Summer Institute will deal with the different viewpoints on the subject of Thermodynamics, as held by physicists, chemists, chemical engineers and mechanical engineers. The General Council approved this Summer Institute proposal and also the request for funds from the National Science Foundation.

The second proposal was for a conference on the integration and correlation of subject matter in mechanics sequences in the engineering curricula. This would include re-evaluation of the instructional material in the physics and engineering courses. It was proposed that this Summer Institute be held at New York University. The conference would bring together about 20 to 25 leading authorities in physics and engineering mechanics instruction. The results of the conference would provide program material for the Physics and Engineering Mechanics Division meetings at the ASEE Annual Meeting at Pennsylvania State University. The General Council approved this conference and recommended that Professor Singer, Chairman of the Engineering Mechanics Division, serve as Chairman of its Planning Committee. The proposal to solicit funds from the National Science Foundation for travel expenses of participants was approved.

A proposal from Lehigh University to hold a similar conference on Electricity and Magnetism, bringing together leading educational authorities of this subject to discuss the integration and correlation of instructional material in electricity and magnetism sequences, as taught in physics and engineering courses, was also approved, and permission was granted to seek funds from the National Science Foundation.

The ad Hoc Committee considering the Summer Institute Proposals also recommended that a Summer Institute be held sometime during 1956 dealing with aspects of "Theoretical Engineering." This conference would explore advanced mathematical methods used in various fields of engineering and physics in an attempt to develop unifying themes and methods of approach which will stress the similarities in mathematical methods. The Council recommended that the Secretary approach Dr. Lindvall at California Institute of Technology to determine whether or not he would be interested in serving as Chairman of the Planning Committee to prepare a proposal. It was suggested that the closed session might be held at California Institute of Technology and the open session at the University of Michigan.

Humanistic-Social Research Project

The progress of the Humanistic-Social Research Project was reviewed. The field committee is now investigating humanistic-social courses and instructional meth-

ods in engineering colleges throughout the country. The director of the project, Dr. George Gullette, is making a tour of the country to examine in detail some of the more successful projects. This material will be presented to the Humanistic-Social Committee for their analysis. This Committee will add its own recommendations of profitable avenues of experimentation. Dr. Edwin S. Burdell is Chairman of the Humanistic-Social Research Committee.

Evaluation of Engineering Education

Dr. Grinter, Chairman of the Committee on Evaluation of Engineering Education, reported that the Interim Report had been very favorably received by educators and industrial people alike and that over 8000 copies have been sold during the five months since the Annual Meeting. This report has been of great help to the ECPD Committee on Education in their their accreditation policies. The General Electric Company sent out approximately 500 copies to leaders in industry. The industrial comments will be reviewed by the Evaluation Committee.

Dr. Grinter mentioned that the civil engineers, in general, were most critical of the report, insisting that young engineering graduates should be educated in such a way as to be able to earn their way during the first year in industry. This would require a considerably greater emphasis on the practice of engineering than is recommended in the Interim Report.

Dr. Grinter mentioned that comments received indicated that considerably more attention should be devoted in the report to the humanistic-social portion of the curricula and also to graduate study. While these are being undertaken as separate studies of the Society, still it was felt that the Committee on Evaluation of Engineering Education should express its own views in these areas. The Evaluation Committee will meet at the Land Grant College Association meeting in November. A meeting of the full committee will probably be held during the month of January or February to complete the recommendations for the final report.

EUSEC

Dean Saville reported that the second international conference of European nations, U.S. and Canada dealing with engineering education in Switzerland met in September. This conference known as EUSEC brought together a wide diversity of viewpoints. Dr. Grinter reported that the Interim Report on Evaluation of Engineering Education had evoked great interest among the delegates present at the conference. He also recommended that invitations be sent to all of the delegates of the EUSEC Conference to attend the ASEE Annual Meeting at Pennsylvania State University in June, 1955.

Graduate Study Project

This item is summarized in the minutes of the Executive Board.

Curricular Specializations

A suggestion has been made that the Society make a comprehensive study of curricular specializations in engineering education. This study would examine from a fresh point of view the structure of engineering curricula and particularly the advantages and disadvantages of retaining the present curricular specializations of electrical, chemical, mechanical, and civil engineering. It would examine various means of achieving greater unity in engineering education and explore the advantages and disadvantages of each. The desirability of such a project had been studied previously by the Executive Board and the Board recommended that an ad hoc committee be appointed to look into the matter. Since the ad hoc Committee met after the Council Meeting, a specific proposal was not available, but it will be referred to the Council at a future meeting.

Learning Aids Bulletin

Professor Carl Muhlenbruch presented a printer's model of the *Learning Aids*

Bulletin, which will be available about the end of December. He stated that over 5000 visual aids were reviewed and that the bulletin describes 290 aids which the reviewing committees regarded as the best available for engineering educational purposes. The cost for the first 1000 bulletins will be $2.50 each. Inasmuch as the Committee has a reserve fund, collected from industry, to subsidize the initial printing, it was recommended that the price be set at $1.00 each. It was also recommended that 2000 copies be ordered in the initial printing.

Reports of Vice Presidents

Vice President H. K. Work reported that the ECRC will publish its Directory and Review of Current Research again this year and that it is also planning a publication of a compilation of papers on the general subject of Creativity in Research. The ECRC is providing helpful service to Directors of Research and Deans on the policy relationships between colleges and government in government sponsored research. A recent study on remuneration policies in research will be published in a forthcoming issue of the *Journal.* Dr. Renato Contini of New York University has been appointed Secretary of ECRC.

Vice President W. L. Everitt stated that the ECAC Executive Committee will meet during the Land Grant College Association meeting in November and therefore no plans have been drawn up for the forthcoming year. However, the various committees of ECAC including Manpower, International Relations, Selection and Guidance, and Secondary Schools are still active in various studies.

Vice Presidents Teare and Lassalle reported respectively on the Section activities and activities of Divisions and Committees. Most of these items are summarized elsewhere in the minutes.

Engineers' Joint Council

Dean Thorndike Saville, the ASEE representative on EJC and President of EJC, reported on the current activities of EJC. He mentioned that a number of amendments to the EJC Constitution and By-Laws had been proposed in order to strengthen the organizational structure of EJC. One of these would enlarge the pool from which the nominating committee of EJC could select its officers. This is essential in order to get the strongest possible people to serve as officers of EJC.

He reported that EJC is forging ahead in many of its important areas of investigation and that channels had been set up to disseminate information on what EJC is doing, so that the members of the constituent societies would be better informed. He mentioned that EJC will hold a symposium on nuclear engineering in the summer of 1955. This will be a collaboration of all of the constituent engineering societies, pooling their various papers in this field.

Life Membership

The General Council voted life membership for the following candidates who meet all the qualifications for membership in ASEE:

Allen, Chester
Christie, A. G.
Daniels, Joseph
Dolve, R. M.
Hastings, Hudson B.
Lohr, William S.
Lovell, A. H.
Rhodes, Sam R.
Savant, D. P.
Setchell, John E.
Trowbridge, D. S.
Turnbull, Wm. D.
White, A. E.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

THE T-SQUARE PAGE

CONTRIBUTIONS TO ENGINEERING EDUCATION

BY THE

DIVISION OF ENGINEERING DRAWING

T. T. AAKHUS, *Chairman*
University of Nebraska

WILLIAM E. STREET, *Vice Chairman*
A & M College of Texas

HAROLD P. SKAMSER, *Secretary-Treasurer*
Michigan State College

IRWIN WLADAVER, *Editor of*
the T-Square Page
New York University

How Important is Graphics to the Practicing Engineer?

By O. W. POTTER

Professor of Drawing and Descriptive Geometry, University of Minnesota

There has been a general trend in recent years to reduce the amount of drawing (graphics) in the engineering undergraduate curriculum. This has brought up many questions, such as: Is this a good thing for the overall training of the engineer? How far is this trend going to go? What does industry think about this? How does the practicing engineer feel about this?

I have been a practicing engineer and teacher for 39 years and I believe that drawing is important in the training of the engineer, and I also think that the proper place to teach it is in our engineering colleges with graduate engineers for teachers.

This past year I have been on sabbatical leave from the University of Minnesota making a study of the importance of graphics in the engineering profession. I have travelled around the country visiting engineering schools, industrial plants, and talking with many practicing engineers. Hundreds of questionnaires have been spread around the country with reference to this problem. The following quotations should be of interest to all in the engineering field. These come from practicing engineers of all ages, they are graduates of many different schools, come from many fields of engineering, all types of industry, and from all parts of the country. These were all received in 1953 or 1954.

Consulting Engineer, North Carolina.
"Impress on students the necessity of every engineer possessing the ability to make a clear concise drawing."

Consulting Engineer, Minnesota.
"Drawings are becoming increasingly more important."

Chief Products Engineer, Manufacturing Co., Ohio.
"Knock the silly idea out of the undergraduate that he is too good to be a draftsman, and that he will never need drawing."

Administrative Engineer, Aircraft Co., New Jersey.
"Creative design along with fundamental training in the principles of graphics should be given more emphasis."

Chief Mechanical Engineer, Steel Casting Co., Ohio.
"Drawings are at all times indispensable in engineering practice."

Chemical Engineer, Coke Manufacturing Co., Penn.

"Drawings are more important now than in former years."

Assistant Chief Engineer, Filtration Plant, Iowa.

"Stress that drafting is an important part of engineering; good designing engineers are in great demand. The fact that the drafting ability of many young engineers is not up to par is probably the main reason why they avoid drafting work."

Project Engineer, Manufacturing Co., Michigan.

"Drawings are more important now than in former years."

Chief Construction Engineer, General Contractors, Michigan.

"Drawings are of prime importance to all engineers."

Laboratory Supervisor, Public Utility, Michigan.

"Drawing is one of the basic tools of the engineer. It would be desirable to include some drawing in the senior year of the undergraduate course where the student could refresh his memory and techniques and apply what has been learned in mathematics, mechanics, and the specialized courses in his field."

Vic Pres., Consulting Engineers, Wisconsin.

"Drawings are extremely important and always will be."

Consulting Engineer, Virginia.

"Judging by our experience with recent young engineering graduates, there has been a decrease in emphasis on drawing in colleges. They have failed to recognize that the ability to prepare a clear drawing or read one is the tool of the engineer, and therefore a prerequisite to real success in that field, especially in design."

Structural Engineer, South Carolina.

"Drawing is absolutely indispensable to the practicing structural engineer."

Director of Research, Manufacturing Co., Mass.

"Drawing is so important as to demand the highest caliber of person for a teacher."

Sales Engineer, Manufacturing Co., Washington.

"It is my opinion that Engineering Drawing is one of the most important and useful courses that an engineer takes."

Design Supervisor, Manufacturing Co., New York.

"Engineers do make freehand sketches in both orthographic and pictorial form. They should know standards, specifications, shop practice, and descriptive geometry so they can supervise the detail draftsman."

Mechanical Engineer, Water Department of large city.

"Drawings are more important now than formerly."

Senior Civil Engineer, Consulting Firm, Texas.

"More actual drawing is needed."

Vice Pres. and Chief Engineer, Public Utility, Alabama.

"Cannot overemphasize the importance of drawing in the undergraduate program."

Assist. Section Mgr., Manufacturing Co., Indiana.

"Some engineering students seem to be given the impression in college that design drafting is a low level assignment. In my opinion, creative design as expressed in a drawing is as high a type of engineering as any."

Mechanical Engineer, Manufacturing Co., New York.

"Drawings are more important than formerly. Drawings are more complicated than formerly, better drafting is needed."

Engineer of Maps and Plans, Highway Department, Conn.

"It is a fact that we have to spend many hours teaching engineering graduates the simple fundamentals of neat draftsmanship directly after they leave the University."

Engineer, Manufacturing Co., New Jersey.

"Do not reduce the time allotted to drawing. Teach more descriptive geometry."

Electrical Engineer, Laboratory Supervisor, Manufacturing Co., Michigan.

"Include some drawing in the later part of the engineering course. Stress free-hand sketching and lettering."

Electrical Engineer, Airplane Mfg. Co., New Jersey.

"Don't lessen the amount of drawing. Creative design and fundamental training of principles should be stressed more."

Flight Test Engineer, Aircraft Co., California.

"Give more stress to assembly and detail drawings."

Consultant, Air Research Laboratory, Colorado.

"Dimensioning, detail and assembly drawing should be stressed more."

Designer, Chemical Co., Delaware.

"More drawing would be desirable."

Names of individuals and companies will be furnished on request.

In the News

A new plan to provide additional financial assistance for American colleges and universities through direct grants of funds was announced by trustees of the **General Electric Educational and Charitable Fund.** The new plan, known as the Corporate Alumnus Program, became effective January 1. It is the intent within limits of the plan that gifts will be made from the fund in amounts equal to those made by G-E employed alumni during 1955. In announcing the plan, Philip D. Reed, Chairman of the G-E Board of Directors and chairman of the Fund's trustees, said the plan "is thought to be unique in business-education circles because it provides for joint participation in the giving program by individual employees who are college graduates, and by the Educational Fund."

Mr. Reed estimated the company employs some 23,000 college graduates with earned degrees from more than 540 U. S. colleges and universities. He said contributions of any such college graduate, up to $1,000 within the year, will be eligible for contributions from the Fund.

The plan further stipulates that contributing employees must have at least a year's service with the General Electric Company; the contributions must be an actual gift and not merely a pledge; and it must be made to an accredited U. S. college or university of which the contributor is an earned degree holder. Mr. Reed said the trustees will consider at the end of 1955 whether the program should be extended, and whether experience has indicated changes that might improve it.

The Corporate Alumnus Program was described by Mr. Reed as "frankly an experiment, arrived at after long consideration of the whole subject of business support for higher education." The trustees of the General Electric Educational and Charitable Fund, he explained, are strongly convinced that one of the greatest untapped sources of continuing support for higher education lies in regular contributions by alumni. With the backing and cooperation of the General Electric Company, the trustees decided that a "corporate alumnus" program, with its provisions for joint action by the alumni and the fund, would do the most to stimulate colleges and universities to develop their own alumni-giving programs and thereby help themselves.

"It is clear that the one who profits most from education is the individual graduate, but undeniably the benefits are shared by the organizations with which he is associated," Mr. Reed said. However, he explained, "in almost every instance, the real cost of a college education was not covered by the tuition paid—usually not more than half of it, in fact. It seems appropriate and fair, therefore, that both the individual and the organization with which he has allied himself should undertake some measure of support for the colleges and universities which play so important a role in American life and progress so that others can participate in those benefits."

Continuing, Mr. Reed said, "this proposition is especially challenging right now, when institutions of higher education are facing higher costs, increased enrollments, and greater demands for educated manpower on the part of industry, science, the professions and government. Their problem is complicated by inadequate or outmoded facilities in many cases, and by overworked teaching staffs which are almost always underpaid."

The G-E board chairman said "it is the hope that other companies may find in this idea an appropriate pattern for incorporation in the educational programs in which they are interested."

New Members

ANGAS, WILLIAM M., Chairman, Department of Civil Engineering, Princeton University, Princeton, N. J. Philip Kissan, F. A. Heacock.

ARMENAKAS, ANTHONY E., Lecturer in Civil Engineering, City College of New York, New York, N. Y. H. G. Lorsch, J. R. Steven.

BAREUTHER, CHARLES A., Head of Physics Department, Drexel Evening College, Philadelphia, Pa. K. W. Riddle, W. J. Stevens.

BARTLETT, ALBERT A., Assistant Professor of Physics, University of Colorado, Boulder, Colo. L. G. Tulin, C. L. Eckel.

BISCHOFF, FREDERICK B., Instructor in Engineering, Lowell Technological Institute, Lowell, Mass. Milton Hindle, M. E. Gelinas.

BISPLIAGHOFF, RAYMOND L., Professor of Aeronautical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. S. Draper, J. A. Hrones.

BOLING, RONALD W., Instructor in Industrial Engineering, University of Tennessee, Knoxville, Tenn. R. M. LaForge, H. P. Emerson.

BRENNER, EGON, Lecturer in Electrical Engineering, The City College of New York, New York, N. Y. Vincent Deltoro, G. J. Clemens.

BYERS, ROLAND O., Assistant Professor of Civil Engineering, University of Idaho, Moscow, Idaho. M. L. Jackson, L. B. Craine.

CLIFFORD, PETER C., Instructor in Building Construction, New York State University, Agricultural and Technological Institute, Delhi, N. Y. F. E. Almstead, W. H. Branch.

CLUTE, VERNON G., Instructor in Machine Shop and Mechanical Drawing, Hudson Valley Technical Institute, Troy, N. Y. O. V. Guenther, J. L. DeLee.

COLES, HENRY L., Head, Department of Chemistry and Chemical Engineering, Michigan College of Mining and Technology, Houghton, Mich. R. F. Makens, M. W. Bredekamp.

DAASCH, HARRY L., Professor and Head of Mechanical Engineering Department, Colorado A. & M. College, Ft. Collins, Colo. D. N. Zwiep, H. B. Mummert.

DATSKO, JOSEPH, Assistant Professor of Production Engineering, University of Michigan, Ann Arbor, Mich. K. E. H. Moltrecht, W. C. Truckenmiller.

EDMONDSON, JAY N., Professor of Industrial Engineering, The Ohio State University, Columbus, Ohio. H. D. Moore, G. B. Carson.

ESHER, FREDERICK N., Assistant Professor of Engineering, Pennsylvania State University, State College, Pa. K. L. Holderman, V. E. Neilly.

FENSTER, SAUL K., Lecturer in Mechanical Engineering, City College of New York, New York, N. Y. H. A. Rothbart, S. J. Tracy.

FULTON, PAUL F., Associate Professor of Petroleum Engineering, University of Pittsburgh, Pittsburgh, Pa. H. G. Botset, W. R. Turkes.

GOODSPEED, HENRY S., JR., Instructor in Mechanics, Lafayette College, Easton, Pa. W. R. Ferrante, W. G. McLean.

GROEN, JOSEPH M., Instructor in Mechanics, Missouri School of Mines, Rolla, Mo. R. F. Davidson, R. A. Schaefer.

HALE, HARRY W., Associate Professor of Electrical Engineering, Purdue University, Lafayette, Indiana. G. V. Mueller, L. E. Beck.

HALLER, KURT, Instructor in Physics, Newark College of Engineering, Newark, N. J. M. R. Weller, T. J. Blisard.

HICKEY, WILLIAM A., Dean of Engineering, Detroit Institute of Technology, Detroit, Mich. E. J. Taylor, P. H. Black.

HILLERY, ARCHIE V., Instructor in Civil Engineering, Ohio Northern University, Ada, Ohio. A. D. Taylor, L. H. Archer.

HUFFMAN, HOWARD L., Instructor in Industrial Engineering, Montana State College, Bozeman, Montana. E. W. Schilling, S. A. Whitt.

HUNT, WILLIAM T., JR., Assistant Professor of Electrical Engineering, City College of

New York, New York, N. Y. H. B. Hansteen.

KEIM, PAUL F., Professor of Civil Engineering, University of California, Berkeley, Calif. A. S. Chase, Bruce Jameyson.

KNOWLTON, CHARLES F., Lecturer in Engineering, University of California, Los Angeles, Calif. C. M. Duke, P. F. O'Brien.

LEHMAN, FREDERICK G., Assistant Professor in Civil Engineering, Newark College of Engineering, Newark, N. J. W. S. LaLonde, Jr., J. M. Robbins.

LEVINE, MARTIN, Instructor in Electrical Engineering, Pennsylvania State University, State College, Pa. K. L. Holderman, V. E. Neilly.

LIEBERMAN, GERALD J., Assistant Professor of Statistics and Industrial Engineering, Stanford University, Stanford, Calif. B. M. Green, E. L. Grant.

LORELL, WILLIAM W., Lecturer in Civil Engineering, City College of New York, New York, N. Y. H. G. Lorsch, J. R. Steven.

MAGNUSSON, LLOYD R., Instructor in General Engineering, Purdue University, Lafayette, Ind. K. E. Botkin, H. C. Thompson.

MAHONE, LESLIE W., Associate Professor of Civil Engineering, University of Arkansas, Fayetteville, Ark. L. R. Heiple, G. F. Branigan.

MCCULLOCH, FRANK W., Manager—Employment and College Relations—Corporate Staff, Radio Corporation of America, Camden, N. J. B. R. Teare, Jr., J. W. Graham.

MCGRAW, JAMES L., Instructor in Technical Institute, University of Dayton, Dayton, Ohio. D. C. Metz, A. J. Morgan.

MCGUIRK, DONALD R., College Employment Coordinator, New York Telephone Company, New York, N. Y. D. S. Bridgman, W. E. Foltz.

MENTZ, PHILIP S., Instructor, Department of Engineering, Purdue University, Lafayette, Ind. W. J. Luzadder, J. H. Porsch.

MERWIN, JOHN E., Instructor in Civil Engineering, The Rice Institute, Houston, Texas. J. R. Sims, L. B. Ryon.

MIDDENDORF, WILLIAM H. H., Assistant Professor of Electrical Engineering, University of Cincinnati, Ohio. H. K. Justice, W. E. Restemeyer.

MILBANK, REGINALD V., Professor and Chairman of Civil Engineering, University of Vermont, Burlington, Vt. S. C. Knight, Jr., E. R. McKee.

NEWCOMB, BRADLEY L., Assistant Professor of Mechanical Engineering, University of Connecticut, Storrs, Conn.

O'DELL, CHARLES W., Lecturer in General Engineering, University of Southern California, Los Angeles, Calif. G. T. Harness, R. E. Vivian.

ROBERTS, DAVID G., Instructor in Product Engineering, General Motors Institute, Flint, Mich. H. M. Dent, C. L. Tutt, Jr.

RUEVE, STEPHEN J., Regent of the College of Engineering and Professor of Philosophy, Marquette University, Milwaukee, Wis. R. J. Panlener, J. E. Matar.

SAVANT, CLEMENT J., JR., Associate Professor of Electrical Engineering, University of Southern California, Los Angeles, Calif. G. T. Harness, R. E. Vivian.

SKORAN, THOMAS E., Instructor in Engineering Graphics, Purdue University, Lafayette, Indiana. W. J. Luzadder, K. E. Botkin.

SOMMERS, B. KLARE, Head of Division of Building Construction, New York State University, Agricultural and Technological Institute, Delhi, N. Y. F. E. Almstead, W. H. Branch.

TUMEINSKI, RONALD F., Instructor in Chemical Engineering, Lafayette College, Easton, Pa. E. L. McMillen, Z. D. Jastrzbski.

VANDERRYN, JACK, Graduate Assistant in Chemistry, Lehigh University, Bethlehem, Pa. G. J. Christensen, E. K. Muhlhansen.

VAN HAM, LOUIS A., Head of Drafting Department, Boston Technical High School, Boston, Mass. E. H. Temple, William Bettencourt.

WAKELAND, HOWARD L., Assistant Dean, College of Engineering, University of Illinois, Urbana, Ill. W. E. Miller, S. H. Pierce.

WALSH, EDWARD J., Executive Director, Foundry Educational Foundation, Cleveland, Ohio. C. J. Freund, G. K. Dreher.

WEINLAND, LOUIS A., Assistant Professor of Chemistry, State University of New York, College of Ceramics, Alfred, N. Y. R. M. Campbell, W. J. Sutton.

263 new members elected this year

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 17, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Brooklyn Polytechnic Institute	Dec. 4, 1954	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	March 26, 1955	M. M. Jones, University of Missouri
National Capital Area	Catholic University	Oct. 5, 1954	J. C. Michalowicz, Catholic University
New England	Massachusetts Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	A.F. Inst. Wright	Sept. 17–18, 1954	K. F. Sibila, University of Akron
	University of Akron	May 7, 1955	
Pacific Northwest	University of Idaho	April 15–16, 1955	M. L. Jackson, University of Idaho
Pacific Southwest	University of California, Berkeley	Dec. 28–29, 1954	B. M. Green, Stanford University
Rocky Mountain	Colorado A. & M. College	April 16, 1955	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9, 1955	V. L. Doughtie, University of Texas
Upper New York	Cornell University	Oct. 22–23, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

Young Engineering Teachers' Paper Contest

RULES

Eligibility: Members of ASEE who are not over 35 years of age (their 36th birthday must not be before June 1, 1955).

Awards: First prize $200—Second prize $100.
Honorable mentions as determined by the Judging Committee.

Presentation of Awards: The awards are known as the "President's Awards." They will be presented to the recipients by the President of the Society at the Annual Banquet at Pennsylvania State University, June, 1955.

Subject: Papers should deal with some constructive phase of improvement of engineering education. Participants are encouraged to use their own judgment in selecting appropriate subject matter.
The following are suggestions of possible subjects:

1. Professional development of the Young Engineering Teacher.
2. How should the student be helped to learn to deal with situations that are new to him, on his own initiative and with well-ordered professional thinking?
3. To what extent should modern physics be included in the engineering curriculum and how should this be done?
4. What areas of physics, chemistry, mathematics and biology not now taught in engineering curricula are likely to be translated into significant engineering practice in the next 25 years and how should this influence present curricula?
5. To what extent and in what manner should undergraduate instruction acquaint the engineering student with the methods of research and with recent research developments in engineering and closely allied sciences?
6. What should be taught of the art of engineering as contrasted with its science?
7. What basic science, mathematics and communication principles and skills can best be taught by separate department staffs and what part by integration into engineering courses?
8. What can be done in college to prepare the young engineer to continue to learn after his formal education is ended?
9. How should non-major courses in engineering such as electrical engineering for non-electricals be planned as to content and method?

Length of Paper: Not to exceed 2500 words.

Submission of Entries: All entries should be submitted to the Chairman of the ASEE Section in which the member resides before March 1, 1955. Names and school affiliations of Section Chairmen are published each month on the page in the Journal of Engineering Education designated "Section Meetings." Papers submitted in the contest last year or in other contests are not eligible for this year's contest.

Judging: Each Section of ASEE will appoint a Judging Committee to select the best paper from the Section. This paper will be submitted to the ASEE Secretary before April 1, 1955.

The winning papers from the various ASEE Sections will be submitted to a Final Judging Committee for the final selection.

Here is an opportunity to gain national distinction. Good luck!

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 1, 1955 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(In Charge of General and Regional Activities—two years)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

Sections and Branches

The Winter Meeting of the Middle Atlantic Section of A.S.E.E. was held December 4, 1954 at the Polytechnic Institute of Brooklyn.

The theme of the general meetings was the integration of the humanistic subjects into an engineering curricula. The speakers and their topics were:

Dr. A. S. Adams, The Role of the Humanities in Engineering Education.

Pres. E. S. Burdell, The Humanities and the Social Studies in the Engineering Curricula.

Dr. J. G. Cavanna, The Humanities in Relation to Science and Engineering at the Polytechnic.

Most of the afternoon was devoted to five group meetings with the following topics:

A. How Shall Modern Scientific Developments Affect the Undergraduate Curricula?
B. How the Old Timers Can Help the Younger Staff Members.
C. Should a Major Research Program, Financed by Industry, Be Undertaken in the Power Field?
D. Thesis?
E. A Workshop for the Humanities and the Social Studies.

Report of the Nominating Committee, Prof. G. B. Thom presented the following names:

Professor C. C. Carr, Chairman, Pratt Institute.
Mr. R. F. Bitner, Vice Chairman, Prentice-Hall, Inc.
Dean D. L. Arm, Member of Council, Univ. of Delaware.

The above members were elected.

Announcement

Professor William Leighton Collins of the University of Illinois is the new executive secretary of the American Society for Engineering Education, President Nathan W. Dougherty announced on January 4.

Professor Collins was elected by the executive board to succeed Professor Arthur Bronwell, who recently resigned when he left Northwestern University to become president of Worcester Polytechnic Institute. Professor Bronwell had served as ASEE secretary for seven years.

The appointment of Professor Collins also means the moving of the ASEE central office from the Northwestern to the Illinois campus. Professor Collins will remain on the Illinois faculty on a half-time basis.

He was born January 8, 1906, in Highland, Illinois. He holds bachelor's and master's degrees in civil engineering from the University of Illinois, whose theoretical and applied mechanics staff he joined in 1929. Besides his teaching he has conducted and directed much research on the properties of engineering materials. He has chairmaned many College and University committees, and headed the University's safety and fire protection board at the time of his ASEE appointment.

He is a registered professional engineer in Illinois.

Over a period of 27 years his industrial experience has included design, construction, operation, research, and consultation work in these fields.

He retired as lieutenant colonel, AUS, in 1953 after having served as commanding officer of the 5000th Research and Development unit, Army Reserve Corps. His World War II service was in ordnance and with the Office of Strategic Services.

Active in the ASEE since 1932, he has participated widely in its regional and national meetings. In 1953 he was elected to a two-year term on the General Council as Engineering Mechanics Division representative. He has resigned from this post and from the national nominating committee. For the 1954 Annual Meeting, held at Illinois, he directed one of the most extensive and demanding activities, that of the housing group.

He has been prominent in the American Society for Testing Materials for fifteen years as member and chairman of many committees. At present he heads the group on methods of testing cast iron.

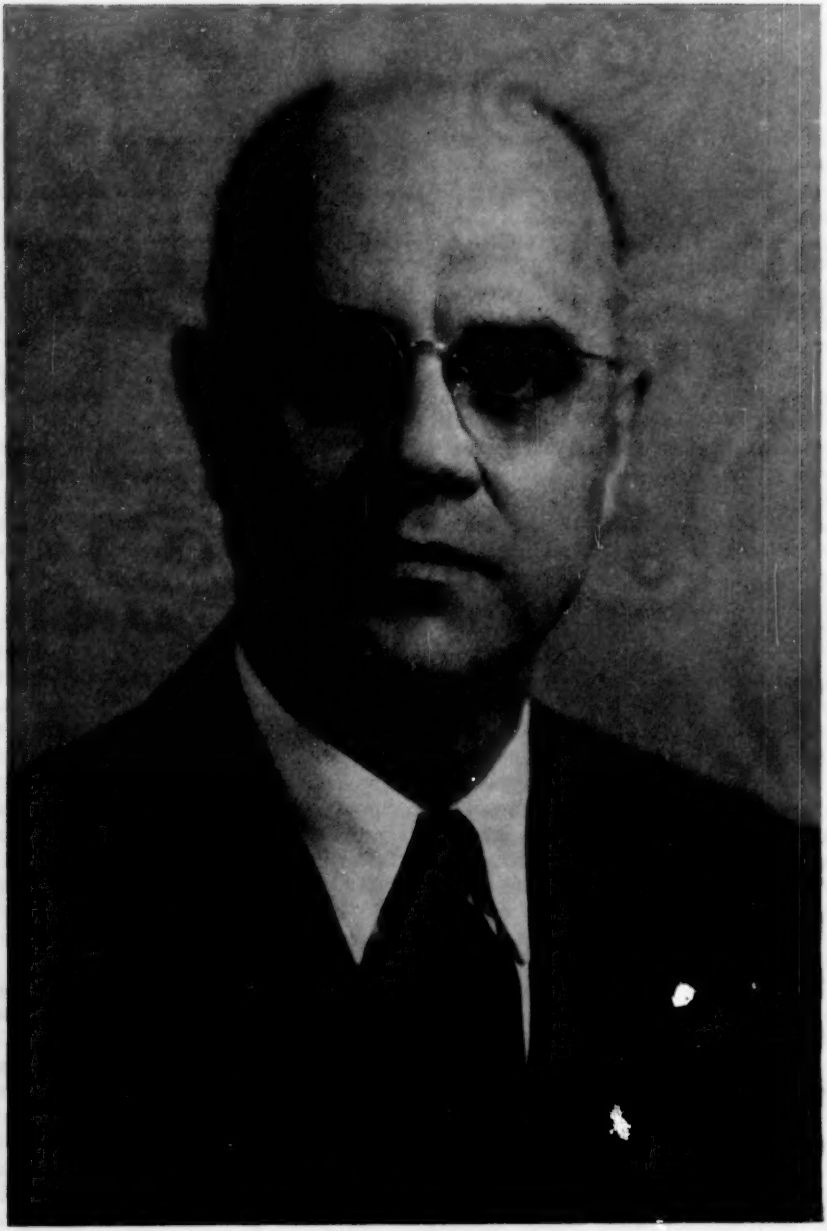
In 1952 he was national president of Gamma Alpha, graduate scientific fraternity. During the same year he headed the Central Illinois Section of the American Society of Civil Engineers.

His other memberships include the American Society for Metals, American Association of University Professors, Sigma Xi, Chi Epsilon, Mu San, Scabbard and Blade, and Rotary. His social fraternity is Alpha Sigma Phi.

As committee chairman, board member, and president he has given long service to the local community chest and other social service organizations.

His publications include "Statics and Strength of Materials," with Professor J. O. Draffin; contributions to the "Cast Metals Handbook"; "Fatigue and Static Load Tests of a High Strength Cast Iron at Elevated Temperatures"; "The Notch Sensitivity of Alloyed Cast Irons Subjected to Repeated and Static Loads" and other technical articles and bulletins.

In 1938 he married Anita Wood, daughter of Mr. and Mrs. Gilbert M. Wood of Urbana. They have two children, Kathryn, 14, and William, 10.



W. L. COLLINS
New Secretary of ASEE

Engineering Enrollments and Degrees, 1954*

By WILLIAM A. JARACZ and HENRY H. ARMSBY **

Engineering enrollment has increased for the third consecutive year—after successive annual declines from a post-World War II high of 244,390 in the fall of 1947 to a post-World War II low of 147,694 in the fall of 1951. There were 187,454 engineering students enrolled (at all levels) in schools accredited by the Engineers' Council for Professional Development in the fall of 1954, an increase of 9.1 per cent over the number enrolled in such schools in the fall of 1953. Although this constitutes a considerable increase, it is a somewhat smaller increase than was experienced by all institutions of higher education, in which total enrollment increased 11.1 per cent, and male enrollment increased 11.8 per cent. This fall's increase of 9.1 per cent continues the trend in the direction of an annual increase in the rate of increase in engineering enrollment. The figure for the fall of 1953 exceeded that for the fall of 1952 by 8.4 per cent; and the 1952 figure exceeded the 1951 figure by 7.3 per cent.

Enrollment of Freshmen

With respect to new student enrollment, the gains made by engineering schools (5.8 per cent) are considerably smaller than those experienced by higher educational institutions generally (12.4 per cent). This difference becomes more pronounced when the 5.8 per cent increase in new engineering students is compared with a 14.9 per cent increase in the first-time male enrollment in higher educational institutions generally.

Unlike total engineering enrollment, which has increased annually at an increasing rate since the fall of 1951, freshmen engineering enrollment has increased at a declining rate: the figure for the fall of 1952 was 34.3 per cent greater than that for 1951, that for 1953 was 14.5 per cent greater than that for 1952, and, as indicated above, that for the fall of 1954 was 5.8 per cent greater than that for the fall of 1953.

A comparison of first-time enrollment for the Nation as a whole with freshmen enrollment in schools accredited by ECPD brings to light certain dissimilarities. The post-World War II low for first-time enrollment in all institutions occurred in the fall of 1951, whereas the corresponding low for the number of engineering freshmen came one year earlier, in 1950. As a result of this, a decline in first-time enrollment in all colleges in the fall of 1951 was accompanied by an increase of 16.2 per cent in the enrollment of engineering freshmen. In 1952 and 1953, there were increases both in total first-time enrollment

* All engineering enrollment and degree data presented in the text of this report are restricted to schools accredited by the ECPD. A report which analyzes engineering enrollment and degree data for all institutions which grant engineering degrees, including those not accredited by the ECPD, will be published in the near future by the U. S. Office of Education.

** Mr. Jaracz is Head, Statistical Services Unit, Research and Statistical Standards Section, U. S. Office of Education, Department of Health, Education, and Welfare. Mr. Armsby is Chief for Engineering Education. The authors would like to acknowledge their indebtedness for contributions made during the several stages in the preparation of this report to the following: Mabel C. Rice, Hazel Poole, Elizabeth Bentson, and Dorothy Gray of the Staff of the Statistical Services Unit; and Ellen S. Scala, secretary to Mr. Armsby.

and in freshmen engineering enrollment, with the latter registering the greater gain. The increase in the enrollment of engineering freshmen in the fall of 1954, however, was, as indicated above, considerably smaller than the increase in first-time students generally, indicating a rather marked reversal in trend.

This conclusion is further borne out by the changes in the ratio of freshmen engineering enrollment to total enrollment of first-time students for the past few years. This ratio increased from 5.7 per cent in 1950 to 7.2 per cent in 1951, to 8.5 per cent in 1952, and to 9.2 per cent in 1953—but declined to 8.6 per cent in the fall of 1954. The declining proportion of freshmen engineering enrollment vis-à-vis the total first-time enrollment is surprising in view of the widespread publicity with respect to the shortage of, and great demand for, engineers.

Undergraduate Enrollment

Undergraduate engineering enrollment, as is true of engineering enrollment generally, has increased for the third consecutive year. The 167,103 undergraduate engineers enrolled in the fall of 1954 represent an increase of 11.1 per cent over the undergraduate engineering enrollment in the fall of 1953. In view of the fact that the increase from 1951 to 1952 was 7.6 per cent, and from 1952 to 1953 was 8.9 per cent, it is apparent that such enrollment has been increasing at an increasing rate.

In terms of percentages, the undergraduate engineering enrollment is distributed by class level as follows: 33.2 per cent are freshmen; 22.9 per cent are sophomores; 17.2 per cent are juniors; and 13.6 per cent are seniors. Approximately 1.4 per cent are 5th year students pursuing 5 year programs, and the remaining 11.7 per cent are part-time and evening students. These ratios are essentially those which obtained in the fall of 1953. There was an increase in enrollment at all class levels with the exception of 5th year students. The situation with respect to part-time and evening students is worthy of note. The enrollment of 19,528 such students in the fall of 1954 constitutes an increase of 15.6 per cent over the fall of 1953 and is an all-time high. This increase is much greater than the increase in total undergraduate engineering enrollment, reflecting the increased interest in such programs.

About 56.0 per cent of all undergraduate engineering students were enrolled in three of the engineering curricula, namely: electrical (22.1 per cent); mechanical (21.0 per cent); and civil (12.9 per cent). The corresponding figures for the fall of 1953 were 55.3 per cent for the three curricula, 20.6 per cent for electrical engineering, 20.9 for mechanical, and 13.9 for civil. The increase of 1.5 percentage points in electrical engineering places it slightly ahead of mechanical engineering in the 1954 ranking, the reverse situation having obtained in the fall of 1953.

Unclassified Undergraduate Enrollment

This fall 94 schools reported a total of 27,232 unclassified students, or 16.3 per cent of the total undergraduate enrollment. The greater part of such students are found in the freshman class and among evening students. Approximately 30.3 per cent of the freshman class, and 44.6 per cent of all undergraduate evening students, were unclassified with respect to the particular engineering discipline which they planned to pursue. In the fall of 1953, on the other hand, 86 schools reported a total of 22,608 unclassified students, or 15.0 per cent of the total undergraduate enrollment. Approximately 28.4 per cent of the freshman class, and 37.0 per cent of undergraduate evening students, were unclassified.

First Degrees

The number of male students upon whom undergraduate engineering degrees

were conferred in 1953–54 was 9.1 per cent smaller than the number of conferrals in the previous year. This is a larger decline than that of 6.6 per cent in the number of first degrees conferred on male students in all institutions of higher education. Of all first degrees granted to men students by all degree-granting institutions in 1953–54, 10.5 per cent were in engineering. This constitutes a decline from the ratio of 10.8 per cent which obtained in 1952–53, which, in turn, was smaller than the 11.9 per cent figure which obtained in 1951–52.

The conferral of first engineering degrees has declined annually since the peak year of 1949–50, when 48,160 were conferred; and reflects the decline in freshman enrollment after the fall of 1946. The 19,707 first engineering degrees conferred in 1953–54 was the smallest number of conferrals since 1946–47, and can be attributed to the fact that the entering freshman class of 1950 was the smallest in the post-World War II period. Beginning with 1954–55, it is expected that the number of first degrees conferred in engineering will increase annually for the foreseeable future, i.e., will reflect the annual increases in freshman enrollment subsequent to the fall of 1950. Rough estimates for the numbers to be conferred in the next three years are as follows: 23,000 in 1954–55, 30,000 in 1955–56, and 35,000 in 1956–57.

Almost two-thirds (63.5 per cent) of all first engineering degrees were conferred in three fields: 24.5 per cent in mechanical engineering; 20.7 per cent in electrical engineering; and 18.3 per cent in civil engineering. The corresponding percentages for 1952–53 approximated these to within one-half of one percentage point in each instance.

Graduate Enrollment

Until the fall of 1954, every post-World War II year has been witness to an increase in graduate engineering enrollment. In the fall of 1954, however, there was a net decline of 1,055 graduate students—consisting of an increase of 278 students enrolled in work leading to a doctoral degree and a decline of 1,333 students enrolled for work leading to a master's or other predoctoral degree. The net decline in the number of students enrolled in work leading to a master's or other predoctoral degree is, in turn, made up of an increase of 212 day students and a decline of 1,545 evening and special students. Approximately 51.4 per cent of all students working towards a master's or other predoctoral degree were evening students in the fall of 1954, as compared with 56.1 per cent in the fall of 1953 and 57.4 per cent in the fall of 1952. A considerably smaller proportion (24.3 per cent) of the students working for doctorates in engineering, on the other hand, are evening students. The ratio was 23.4 per cent in the fall of 1953, and 22.8 per cent in the fall of 1952. There appears to have been a slightly decreasing emphasis on evening enrollment insofar as master's and other predoctoral enrollment is concerned, and a slightly increasing emphasis with respect to doctoral enrollment.

The decline in the number of graduate students is surprising in view of the existing demand for engineers with advanced educational attainment. The large proportion of graduate engineering students who are evening students does, however, indicate an awareness on the part of practicing engineers of the necessity of, and the benefits to be derived from, bettering their understanding of the complex engineering processes which are constantly being developed.

In view of the fact that graduate engineering enrollment declined from the fall of 1953 to the fall of 1954, while undergraduate engineering enrollment increased, graduate engineering enrollment constituted a smaller proportion of total engineering enrollment in the fall of 1954 than in the previous fall. These ratios

for the past four years from 1951 to 1954, respectively, are: 13.1 per cent, 12.8 per cent, 12.5 per cent, and 10.9 per cent—indicating what appears to be a trend in the direction of a decline in the relative attractiveness of graduate engineering enrollment. The ratio of resident graduate enrollment to total resident enrollment for the college population as a whole was 10.1 per cent in the fall of 1953 (the latest date for which such data are available).

Although the largest number of undergraduate students are found in electrical, mechanical, and civil engineering, the 1954 data show chemical engineering replacing civil engineering as one of the big three insofar as graduate engineering enrollment is concerned. The enrollment in civil engineering at the master's level is larger than that in chemical engineering; however, the enrollment in chemical engineering at the doctoral level far exceeds the enrollment in civil engineering.

Approximately two-fifths (59.6 per cent) of all graduate engineering students are enrolled in electrical, mechanical, and chemical engineering. Graduate students in electrical engineering accounted for 31.0 per cent of the total graduate engineering enrollment, the corresponding proportions for mechanical and chemical engineering being 17.0 per cent and 11.5 per cent, respectively. The change in these ratios since the fall of 1953 was less than 0.5 percentage point in each instance.

Graduate Degrees

There was an 11.4 per cent increase in the number of engineering master's degrees conferred in 1953–54 as compared with 1952–53. This increase stands in marked contrast with the decline of 6.9 per cent in the number of master's degrees conferred by all institutions of higher education; and is a considerable change from the situation prevailing in 1951–52 and 1952–53, in each of which years fewer master's degrees in engineering were conferred than in the preceding year.

There were 590 doctorates conferred in engineering in 1953–54 as compared with 592 in 1952–53, i.e., a decline of 2. There was, on the other hand, an increase of 8.3 per cent in the number of doctorates conferred by all degree-granting institutions.

Notes

The data contained in this report are based on a survey of engineering schools and colleges made in October 1954, under the joint sponsorship of the U. S. Office of Education and the American Society for Engineering Education. In accordance with an agreement reached by a joint committee of the Office of Education and the ASEE, all institutions listed in the Office of Education Directory of Higher Education [1] which reported that they conferred degrees in engineering during 1953–54 [2] were requested to supply data. Ten Canadian institutions were also invited to participate in the study. This report contains enrollment and degree data for all institutions accredited by the ECPD, 68 other United States institutions, and 10 Canadian institutions.

As proposed by the joint ASEE and Office of Education Committee and approved by the ASEE general council, the statistical tables in this report list individually only the ECPD accredited institutions (eligible for active institutional membership in the ASEE), but contain summary totals for other United State institutions and for Canadian institutions.

Requests for the data upon which this report is based were directed to the registrars of the institutions concerned. This changes the prior practice of requesting these data from the deans of engineering,

[1] *Education Directory, Part III, Higher Education, 1953–54* (U. S. Office of Education).

[2] *Earned Degrees Conferred in Higher Educational Institutions, 1953–54, Circular No. 418* (U. S. Office of Education).

a change which was approved by the ASEE general council. The Office of Education appreciates the splendid cooperation of the registrars.

Period covered: Engineering schools were asked to report student enrollment as of October 4, 1954. A few institutions, because of late openings, were unable to report before November. Degree data are for the period July 1, 1953 to June 30, 1954.

Undergraduate students: Institutions were requested to report by class level only those students enrolled definitely as candidates for an engineering degree. "Part-time students" (both day and evening) may include students not working toward a degree, as well as degree candidates.

Graduate students: Institutions were requested to "report all students who have been admitted to formal graduate standing and are enrolled in graduate courses regardless of the number of credit hours carried by the student, and regardless of whether the student's work is administered by the engineering college or the graduate school."

PRE-WAR AND POST-WAR COMPARISON OF ENGINEERING COLLEGE ENROLLMENTS AND DEGREES

(for United States and outlying parts)

Undergraduate Enrollment and Degrees

Year	Freshmen	Sophomore	Junior	Senior	5th Year	Part Time and Evening	Total	No. of First Degrees
1940	33,175	24,242	20,120	16,310	985	14,079	108,911	11,358 (1939–40)
1947	57,507	71,615	48,227	32,369	1,846	18,616	230,180	18,592 (1946–47)
1948	47,672	52,949	59,945	45,695	1,924	17,932	226,117	27,460 (1947–48)
1949*	36,508	35,648	41,695	50,991	2,326	13,478	180,646	41,793 (1948–49)
1950*	29,394	27,242	30,957	37,707	3,150	14,504	142,954	48,160 (1949–50)
1951*	34,147	23,408	24,757	27,820	2,946	15,289	128,367	37,904 (1950–51)
1952*	45,854	26,636	22,369	23,453	2,563	17,295	138,170	27,155 (1951–52)
1953*	52,482	32,953	23,975	21,730	2,396	16,890	150,426	21,642 (1952–53)
1954*	55,531	38,345	28,699	22,677	2,323	19,528	167,103	19,707 (1953–54)

Graduate Enrollment and Degrees

	Master's Degrees and Other Pre-Doctoral Degrees					Doctor's Degrees				
Year	Full Time	Part Time	Evening	Total	Master's and Other Pre-Doctoral Degrees	Full Time	Part Time	Evening	Total	Doctor's Degrees
1940	2,003	980	1,599	4,582	1,318 (1939–40)	404	179	41	624	108 (1939–40)
1947	5,465	3,663	3,515	12,643	3,090 (1946–47)	704	784	79	1,567	127 (1946–47)
1948	6,138	2,348	4,882	13,368	4,303 (1947–48)	1,046	569	454	2,069	252 (1947–48)
1949*	6,277	4,056	4,746	15,079	4,783 (1948–49)	1,593	793	155	2,541	417 (1948–49)
1950*	8,150		7,425	15,575	4,865 (1949–50)	2,342		453	2,795	492 (1949–50)
1951*	6,878		9,574	16,452	5,134 (1950–51)	2,419		456	2,875	586 (1950–51)
1952*	7,422		9,996	17,418	4,132 (1951–52)	2,261		669	2,930	586 (1951–52)
1953*	8,084		10,321	18,405	3,726 (1952–53)	2,298		703	3,001	592 (1952–53)
1954*	8,296		8,776	17,072	4,130 (1953–54)	2,483		796	3,279	590 (1953–54)

	1940	1947	1948	1949	1950	1951	1952	1953	1954
Total college enrollment in U. S.**	1,490,000	2,333,000	2,410,000	2,456,000	2,297,000	2,116,000	2,148,000	2,251,000	2,499,750
Engineering enrollment in U. S.**	113,497	244,390	241,554	198,266*	161,324*	147,694*	158,518*	171,832*	187,454*
Per cent engineering to total	7.6%	10.5%	10.0%	8.0%*	7.0%*	7.0%*	7.4%*	7.6%*	7.5%*

* Includes only ECPD accredited institutions. ** Includes outlying parts.

Summary of Undergraduate Enrollments and Bachelor's or First Professional Degrees in Engineering in the United States, Outlying Parts, and Canada, by Curriculum: 1954

Engineering Curriculum	No. of Schools[1]	Enrollment										First Engineering Degrees 1953–54	
		1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
										Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Schools accredited by ECPD:													
Aeronautical	48	1,823	1,423	1,030	774	47	11	41	208	5,331	26	605	1
Agricultural	38	473	383	317	269	15	—	4	—	1,461	—	264	—
Architectural	26	635	519	421	468	124	1	15	36	2,182	37	377	4
Ceramic	14	150	145	113	90	7	—	10	—	501	14	113	—
Chemical	107	4,503	4,075	2,986	2,180	127	159	114	606	14,595	155	1,980	8
Civil	137	5,816	5,403	4,406	3,992	186	199	192	1,366	21,476	84	3,590	7
Electrical	138	10,381	9,938	7,373	5,035	204	328	376	3,352	36,873	114	4,066	10
Engineering Mechanics	2	—	26	18	13	—	—	—	—	55	2	6	—
Engineering Physics	30	382	402	366	246	31	6	7	18	1,440	18	215	4
General Engineering	25	1,011	876	680	566	3	—	143	470	3,728	21	501	2
Geological	25	445	301	253	228	6	—	2	7	1,239	3	185	1
Industrial[2]	65	1,052	1,316	1,361	1,348	66	39	80	328	5,561	29	1,099	4
Mechanical	133	9,215	9,089	7,077	5,576	322	324	368	3,155	35,027	99	4,818	9
Metallurgical	48	451	586	562	476	21	28	40	150	2,307	7	483	3
Mining	31	281	276	240	228	10	—	6	4	1,042	3	230	1
Naval Arch. & Marine	3	29	52	51	46	—	—	2	—	179	1	46	—
Petroleum	22	1,291	1,003	827	674	29	—	8	98	3,920	10	460	—
Sanitary	4	3	4	7	16	—	—	1	—	30	1	13	—
Textile	5	231	163	124	140	—	—	—	—	657	1	82	—
Unclassified	94	16,812	1,985	122	16	—	—	404	7,893	26,919	313	22	—
Other	36	547	380	365	296	30	—	23	1	1,623	19	495	3
Total ECPD	150	55,531	38,345	28,699	22,677	1,228	1,095	1,836	17,692	166,146	957	19,650	57
Other U. S. Schools	68	9,974	5,729	3,642	2,870	117	254	769	3,234	26,469	120	2,524	5
All U. S. Schools	218	65,505	44,074	32,341	25,547	1,345	1,349	2,605	20,926	192,615	1,077	22,174	62
Canadian Schools	10	2,520	1,841	1,477	1,239	285	—	6	161	7,512	17	1,035	1
Grand Total (U. S. and Canada)	228	68,025	45,915	33,818	26,786	1,630	1,349	2,611	21,087	200,127	1,094	23,209	63

[1] This refers to the number of schools offering given curriculum. Such curriculum may or may not be specifically approved by ECPD.
[2] Includes administrative engineering, management engineering, etc.

Undergraduate Engineering Enrollment as of October 4, 1954, and First Engineering Degrees Conferred in 1953–54, by School

Institution	Enrollment										First Engineering Degrees 1953–54	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
ECPD accredited schools:												
Alabama												
Ala. Poly.	861	515	348	221	—	—	2	—	1,941	6	203	—
Univ. Ala.	340	254	152	97	—	—	4	623	1,455	15	79	—
Arizona												
Univ. Aris.	369	261	183	173	—	—	9	—	987	8	107	1
Arkansas												
Univ. Ark.	220	235	139	102	—	—	2	6	702	2	73	—
California												
Calif. Tech.	105	85	78	71	—	—	—	—	339	—	59	—
Santa Clara	110	76	56	43	12	—	—	—	297	—	35	—
Stanford	380	183	158	152	—	—	—	—	869	4	110	1
Univ. Calif. (B)	328	365	467	419	—	—	25	—	1,592	12	333	—
Univ. Calif. (LA)	274	283	318	183	—	—	1	—	1,053	6	151	—
Univ. Southern Calif.	137	170	258	251	—	—	53	185	1,050	4	225	1
U. S. Naval PG Sch.	—	—	136	169	—	—	—	—	304	1	242	—
Colorado												
Colo. A. & M.	219	120	98	72	—	—	—	—	509	—	51	—
Colo. Mines	380	242	186	138	—	—	—	—	946	—	173	—
Univ. Denver	102	69	69	44	—	2	22	6	311	3	59	—
Univ. Colo.	727	417	354	259	30	—	5	525	2,299	18	213	2
Connecticut												
U. S. Coast Guard	176	106	101	78	—	—	—	—	461	—	88	—
Univ. Conn.	522	308	170	120	—	—	—	—	1,113	7	93	—
Yale Univ.	—	233	214	173	—	—	2	—	622	—	170	—
Delaware												
Univ. Delaware	168	131	108	71	—	—	7	—	479	6	41	—
Florida												
Univ. Florida	569	360	247	182	44	—	—	—	1,400	2	135	—
Georgia												
Ga. Tech.	1,560	1,032	603	580	20	—	—	—	3,782	13	473	—

Idaho												
Univ. Idaho	249	151	137	95	—	—	—	—	629	3	64	—
Illinois												
Bradley	171	96	65	67	—	—	3	33	434	1	56	—
Ill. Inst. Tech.	401	294	271	232	—	9	8	3,963	4,998	180	286	—
Northwestern	235	149	157	108	—	103	27	68	841	6	96	1
Univ. Ill.	1,695	1,052	839	815	—	—	43	—	4,417	27	424	1
Indiana												
Notre Dame	442	268	256	161	—	—	—	—	1,127	—	171	—
Purdue	1,533	1,200	984	813	—	—	2	—	4,500	32	655	2
Rose Poly.	140	105	86	55	—	—	3q	—	389	—	38	—
Iowa												
Iowa St. Coll.	1,161	674	501	301	—	—	12	—	2,629	20	250	1
St. Univ. Iowa	218	129	78	68	—	—	—	—	492	1	64	—
Kansas												
Kan. St. Coll.	414	301	167	156	—	—	13	—	1,044	7	131	1
Kan. Univ.	462	336	327	225	—	—	2	—	1,341	11	144	1
Wichita	361	83	37	27	—	—	89	129	725	1	20	—
Kentucky												
Ky. Univ.	492	328	192	137	—	—	21	—	1,167	3	129	—
Louisville	140	135	56	46	61	55	3	—	496	—	74	—
Louisiana												
Louisiana Poly.	378	174	123	85	—	—	—	—	758	2	47	—
Louisiana St. Univ.	700	302	312	279	—	—	—	—	1,573	20	131	—
Tulane Univ.	239	122	81	51	—	—	—	—	491	2	58	—
Maine												
Univ. Maine	358	240	167	120	9	—	10	—	895	9	128	1
Maryland												
Johns Hopkins	128	140	121	108	—	—	5	466	968	—	146	—
Md. Univ.	570	349	125	123	—	—	37	—	1,193	11	106	—
Massachusetts												
Harvard	—	66	32	23	—	—	—	—	121	—	27	—
Lowell Tech.	217	93	46	42	—	—	—	—	398	—	47	—
Mass. Inst. Tech.	754	624	710	580	—	—	—	—	2,649	19	499	10
Mass. Univ.	313	213	115	86	—	—	—	20	738	9	44	1
Northeastern	746	571	407	252	—	279	—	—	2,246	9	284	2
Tufts	200	163	126	102	—	—	—	—	582	9	93	—
Worcester	282	196	146	123	—	—	—	—	747	—	110	—
Michigan												
Detroit Univ.	528	273	225	182	—	140	47	218	1,608	5	213	—
Mich. M. & T.	505	426	270	189	—	—	2	—	1,388	4	169	2
Mich. St. Coll.	664	426	352	342	—	—	—	—	1,779	5	207	—
Mich. Univ.	649	746	461	359	—	—	49	—	2,244	20	330	—
Wayne Univ.	461	319	222	195	99	—	84	—	1,360	20	118	—
Minnesota												
Univ. Minn.	697	513	481	312	250	—	38	—	2,281	10	223	—
Mississippi												
Miss. St. Coll.	297	241	198	104	1	—	—	—	838	3	89	—
Miss. Univ.	61	49	43	32	—	—	—	—	182	3	13	—

Undergraduate Engineering Enrollment as of October 4, 1954—*Continued*

Institution	Enrollment										First Engineering Degrees 1953–54	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Missouri												
Mo. Mines	455	352	275	260	—	—	—	—	1,339	3	178	—
Mo. Univ.	412	251	188	118	—	—	6	—	970	5	75	—
St. Louis Univ.	212	133	79	56	—	—	10	5	493	2	124	—
Wash. Univ. (St. L.)	270	215	185	131	—	—	—	—	796	5	114	1
Montana												
Mont. St. Coll.	303	199	83	103	—	—	—	—	684	4	74	—
Mont. Mines	78	61	36	36	—	—	—	—	211	—	28	—
Nebraska												
Nebr. Univ.	437	274	144	109	—	—	—	—	961	3	121	—
Nevada												
Nevada Univ.	151	82	54	42	1	—	—	—	329	1	46	—
New Hampshire												
Dartmouth	142	84	42	26	29	—	—	—	323	—	32	—
New Hamp. Univ.	220	144	103	70	—	—	39	—	575	1	60	—
New Jersey												
Newark	423	419	286	188	—	—	—	1,121	2,412	25	229	3
Princeton	170	128	127	131	—	—	—	—	556	—	90	—
Rutgers	205	133	91	77	—	—	6	—	507	5	48	1
Stevens	287	230	172	130	—	—	—	—	819	—	123	—
New Mexico												
N. Mex. A. & M.	246	166	80	47	—	—	43	158	734	6	44	—
N. Mex. Univ.	265	145	109	86	—	—	—	—	601	4	62	1
New York												
Alfred	72	55	48	33	—	—	5	—	205	8	40	—
Brooklyn Poly.	467	407	385	228	—	—	—	1,784	3,271	—	366	—
Clarkson	340	227	144	145	—	—	—	—	856	—	112	—
City Coll. of N. Y.	1,567	853	603	468	—	—	—	1,073	4,526	38	338	3
Columbia	—	—	158	119	—	—	—	—	273	4	98	1
Cooper Union	105	107	67	72	—	—	—	428	766	13	70	—
Cornell	508	446	253	240	238	14	3		1,689	13	263	1
Manhattan	344	242	221	159	—	—	5	—	971	—	104	—
N. Y. Univ.	324	286	295	199	—	—	19	1,028	2,143	8	330	—
Pratt	87	81	49	32	—	—	2	—	248	3	35	—
Rensselaer	715	652	421	481	—	—	3	—	2,270	2	432	—
Rochester	89	62	46	41	—	—	81	—	316	3	30	1
Syracuse	202	132	97	105	—	—	—	—	534	2	95	2
Union Coll.	131	103	58	31	—	—	—	45	368	—	34	—
Webb	18	16	11	16	—	—	—	—	61	—	13	—

North Carolina												
Duke Univ.	173	137	99	68	—	—	3	—	480	—	77	—
N. C. St. Coll.	950	591	340	287	14	—	—	—	2,181	1	241	—
North Dakota												
N. Dak. Ag. Coll.	220	160	128	87	—	—	2	—	597	—	68	—
N. Dak. Univ.	176	141	77	55	—	—	—	—	448	1	41	—
Ohio												
Akron	224	63	40	33	—	23	2	44	426	3	39	—
Case Inst.	313	304	274	188	—	—	22	31	1,131	1	210	—
Cincinnati	359	331	238	164	—	195	—	1,664	2,943	8	203	1
Fenn	198	110	79	40	—	55	—	801	1,279	4	103	—
Ohio St. Univ.	878	526	324	253	209	—	38	257	2,475	10	227	—
Ohio No. Univ.	53	30	23	15	—	—	—	—	121	—	14	—
Ohio Univ.	295	176	120	104	—	—	—	—	694	1	60	—
Toledo	316	178	85	69	—	—	5	525	1,178	—	70	—
Univ. Dayton	311	95	68	33	—	—	13	246	760	6	36	—
Youngstown	217	129	75	40	—	—	376	—	834	3	40	—
Oklahoma												
Okla. A. & M.	572	395	381	286	25	—	1	—	1,653	7	186	1
Okla. Univ.	769	472	430	297	—	—	—	—	1,960	8	246	1
Tulsa	217	157	117	83	—	—	6	91	667	4	86	—
Oregon												
Oregon State	418	341	123	170	—	—	347	—	1,396	3	140	—
Pennsylvania												
Bucknell	143	77	70	39	—	—	5	—	331	3	42	—
Carnegie	340	309	270	220	—	—	17	521	1,672	5	256	—
Drexel	435	511	260	210	—	178	16	315	1,905	20	358	3
Lafayette	188	181	133	92	—	—	—	96	690	—	70	—
Lehigh	568	423	350	248	—	—	—	—	1,589	—	269	—
Pa. St. Univ.	1,403	890	669	511	10	—	—	—	3,464	19	397	—
Pittsburgh	500	401	240	199	—	—	—	470	1,799	11	207	2
Swarthmore	30	30	23	20	—	—	—	—	101	2	14	—
Univ. Pa.	143	119	95	51	2	—	—	—	409	1	61	—
Villanova	280	204	137	81	10	—	—	—	712	—	65	—
Rhode Island												
Brown	119	68	53	23	9	—	—	—	272	—	38	—
R. I. Univ.	210	138	88	62	—	—	17	—	511	4	61	1
South Carolina												
Citadel	192	112	76	63	—	—	—	—	443	—	51	—
Clemson	577	310	208	126	—	—	—	—	1,221	—	165	—
S. C. Univ.	288	166	100	77	—	—	—	—	629	2	59	—
South Dakota												
S. Dak. Mines	288	107	136	75	—	—	—	—	604	2	57	1
S. Dak. St. Coll.	234	164	71	46	—	—	2	—	515	2	25	—
Tennessee												
Tenn. Univ.	420	394	282	188	—	—	—	—	1,267	17	138	—
Vanderbilt	189	147	130	98	—	—	—	—	558	6	77	1

Undergraduate Engineering Enrollment as of October 4, 1954—*Continued*

Institution	Enrollment										First Engineering Degrees 1953–54	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Texas												
A. & M. Coll. Texas	1,052	619	436	548	70	—	23	—	2,748	—	376	—
Rice	152	135	90	70	54	—	—	—	495	6	45	1
Southern Meth.	148	103	88	43	—	42	13	219	654	2	62	—
Tex. Coll. A. & I.	160	143	57	35	—	—	—	—	394	1	23	—
Tex. Tech. Coll.	563	348	221	176	—	—	—	—	1,304	4	118	—
Tex. Western	220	97	47	44	—	—	—	199	602	5	46	—
Tex. Univ.	890	752	639	394	—	—	—	—	2,664	11	282	—
Utah												
Utah Ag. Coll.	149	101	92	51	—	—	—	—	392	1	48	—
Utah Univ.	155	172	117	233	—	—	8	—	682	3	107	—
Vermont												
Norwich	97	79	45	46	—	—	—	—	267	—	32	—
Vermont Univ.	102	81	53	35	—	—	7	—	278	—	34	—
Virginia												
Va. Mil. Inst.	150	100	90	115	—	—	—	—	455	—	68	—
Va. Poly.	946	486	315	240	—	—	26	—	1,999	14	183	1
Va. Univ.	163	190	117	62	—	—	2	—	531	3	40	—
Washington												
Wash. St. Coll.	275	140	151	125	27	—	—	—	718	—	93	—
Wash. Univ.	811	377	332	311	3	—	—	—	1,826	8	261	1
West Virginia												
W. Va. Univ.	286	277	158	91	—	—	—	—	807	5	90	—
Wisconsin												
Marquette	314	282	200	174	—	—	4	329	1,299	4	152	—
Univ. Wisc.	1,163	668	396	350	—	—	—	—	2,571	6	247	1
Wyoming												
Wyoming Univ.	157	121	86	94	—	—	8	—	462	4	49	—
District of Columbia												
Catholic Univ.	77	18	63	53	—	—	15	—	226	—	58	—
Geo. Wash. Univ.	301	129	95	26	—	—	—	—	547	4	67	—
Howard Univ.	157	53	24	31	—	—	1	—	265	1	21	—
Alaska												
Univ. Alaska	44	26	16	14	1	—	5	—	102	4	11	—
Hawaii												
Univ. Hawaii	140	84	90	43	—	—	—	—	357	—	35	—
Total ECPD Schools	55,531	38,345	28,699	22,677	1,228	1,095	1,836	17,692	166,146	957	19,650	57

Summary of Graduate Enrollment and Degrees in Engineering, in the United States, Outlying Parts, and Canada, by Curriculum: 1954

Engineering Curriculum	No. of Schools[1]	Number Enrolled in Work for the Master's Degree				Master's Degrees in Eng'g 1953–54		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[2]				Post-Grad. Degrees[2] in Eng'g 1953–54		Number Enrolled in Work for the Doctor's Degree				Doctor's Degrees in Eng'g 1953–54	
		Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
				Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
ECPD accredited schools:																			
Aeronautical	38	344	305	645	4	198	1	26	—	26	—	20	—	123	45	166	2	43	—
Agricultural	30	113	2	115	—	47	—	—	—	—	—	—	—	29	—	29	—	7	—
Architectural	12	46	1	46	1	12	—	—	—	—	—	—	—	1	—	1	—	—	—
Ceramic	14	77	—	75	2	34	—	—	—	—	—	—	—	34	—	34	—	16	—
Chemical	88	929	791	1,706	14	443	2	5	—	5	—	3	—	517	105	622	—	133	—
Civil	99	1,177	707	1,881	3	555	3	12	4	16	—	5	—	189	150	338	1	43	—
Electrical	102	1,914	3,467	5,365	16	959	1	45	—	45	—	18	—	638	254	890	2	111	—
Engineering Mechanics	26	152	61	213	—	44	—	—	—	—	—	—	—	85	1	85	1	25	—
Engineering Physics	18	113	28	137	4	74	—	2	—	2	—	4	—	98	2	99	1	18	—
General Engineering	8	116	7	123	—	61	1	—	—	—	—	—	—	31	—	30	1	8	—
Geological	13	98	—	95	3	9	—	—	—	—	—	—	—	30	—	28	2	2	—
Industrial[3]	42	563	918	1,477	4	365	2	6	—	6	—	—	—	46	45	91	—	5	1
Mechanical	99	1,390	1,609	2,996	3	698	—	38	3	41	—	12	—	281	140	420	1	72	—
Metallurgical	40	269	220	488	1	134	2	4	—	4	—	3	—	203	40	241	2	53	—
Mining	19	57	7	64	—	22	—	—	—	—	—	—	—	9	—	9	—	3	—
Naval Arch. & Marine	3	19	—	19	—	20	—	84	—	84	—	29	—	—	—	—	—	—	—
Petroleum	13	96	69	165	—	59	—	—	—	—	—	—	—	15	—	15	—	6	—
Sanitary	16	72	4	76	—	60	—	1	—	1	—	3	—	27	6	33	—	6	—
Textile	3	30	—	29	1	10	1	—	—	—	—	—	—	2	—	2	—	—	—
Unclassified	18	257	353	603	7	69	—	—	—	—	—	—	—	—	—	—	—	—	—
Other	31	235	220	451	4	145	—	6	—	6	—	2	—	125	8	131	2	38	—
Total ECPD	128	8,067	8,769	16,769	67	4,018	13	229	7	236	—	99	—	2,483	796	3,264	15	589	1
Other U. S. Schools	4	181	188	367	2	47	—	—	—	—	—	—	—	2	—	2	—	—	—
All U. S. Schools	132	8,248	8,957	17,136	69	4,065	13	229	7	236	—	99	—	2,485	796	3,266	15	589	1
Canadian Schools	9	167	—	166	1	90	—	—	—	—	—	—	—	68	—	68	—	23	—
Grand Total (U. S. and Canada)	141	8,415	8,957	17,302	70	4,155	13	229	7	236	—	99	—	2,553	796	3,334	15	612	1

[1] This refers to the number of schools offering given curriculum. Such curriculum may or may not be specifically approved by ECPD.
[2] Other engineering degrees requiring work beyond the Master's degree, but less than the requirements for a Doctor's degree.
[3] Includes administrative engineering, management engineering, etc.

Graduate Engineering Enrollment as of October 4, 1954, and Graduate Engineering Degrees Conferred in 1953–54, by School

Institutions	Number Enrolled in Work for the Master's Degree				Master's Degrees in Eng'g 1953–54		Number Enrolled in Work for Post-Graduate Pre-Doctoral Degrees[1]				Post-Grad. Degrees[1] in Eng'g 1953–54		Number Enrolled in Work for the Doctor's Degree				Doctor's Degrees in Eng'g 1953–54	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
ECPD accredited schools:																		
Alabama																		
Ala. Poly	17	—	17	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Ala	15	—	15	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Arizona																		
Univ. Ariz	32	58	89	1	4	—	—	—	—	—	—	—	9	—	9	—	—	—
Arkansas																		
Univ. Ark	17	8	25	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—
California																		
Calif. Tech	85	—	85	—	67	—	45	—	45	—	18	—	69	2	71	—	34	—
Stanford	226	—	226	—	114	—	28	—	28	—	17	—	66	—	66	—	22	—
Univ. Calif. (B)	152	—	149	3	59	—	—	—	—	—	—	—	53	—	53	—	24	—
Univ. Calif. (LA)	233	—	233	—	41	1	—	—	—	—	—	—	66	—	65	1	7	—
Univ. Southern Calif	269	211	479	1	105	—	7	—	7	—	2	—	16	—	16	—	—	—
U. S. Naval PG Sch	81	—	80	1	60	—	—	—	—	—	—	—	—	—	—	—	—	—
Colorado																		
Colo. A. & M	20	—	20	—	4	—	—	—	—	—	—	—	4	—	4	—	—	—
Colo. Mines	33	—	33	—	11	—	—	—	—	—	—	—	17	—	17	—	8	—
Univ. Denver	—	10	10	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Colo	44	72	115	1	16	—	—	—	—	—	—	—	6	232	237	1	4	—
Connecticut																		
Univ. Conn	12	200	212	—	24	—	—	—	—	—	—	—	—	—	—	—	—	—
Yale Univ	57	3	59	1	26	1	—	—	—	—	—	—	57	—	57	—	4	—
Delaware																		
Univ. Delaware	197	—	197	—	33	—	—	—	—	—	—	—	18	—	18	—	6	—
Florida																		
Univ. Florida	36	—	35	1	13	—	—	—	—	—	—	—	4	—	4	—	3	—
Georgia																		
Ga. Tech	193	—	192	1	66	—	—	—	—	—	—	—	28	—	28	—	4	—
Idaho																		
Univ. Idaho	14	—	14	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—

Illinois																		
Univ. Ill.	242	—	241	1	141	—	—	—	—	—	—	—	140	—	140	—	44	—
Bradley	5	—	5	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Northwestern	57	58	115	—	25	—	—	—	—	—	—	—	49	—	49	—	8	—
Ill. Inst. Tech.	48	349	397	—	61	—	—	—	—	—	—	—	13	92	104	1	5	—
Indiana																		
Notre Dame	37	14	51	—	18	—	—	—	—	—	—	—	2	—	2	—	1	—
Purdue	292	—	292	—	131	—	—	—	—	—	—	—	82	—	82	—	28	—
Rose Poly	3	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Iowa																		
Iowa St. Coll.	91	—	91	—	23	—	—	—	—	—	—	—	49	—	49	—	19	—
St. Univ. Iowa	51	1	52	—	30	—	—	—	—	—	—	—	24	2	26	—	9	—
Kansas																		
Kan. St. Coll.	26	—	26	—	10	—	—	—	—	—	—	—	2	—	2	—	—	—
Kan. Univ.	117	—	117	—	11	—	—	—	—	—	—	—	11	—	11	—	—	—
Wichita	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Kentucky																		
Ky. Univ.	30	—	30	—	17	—	—	—	—	—	—	—	2	—	2	—	1	—
Louisville	14	50	64	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—
Louisiana																		
Louisiana St. Univ.	36	—	36	—	11	—	—	—	—	—	—	—	5	5	10	—	—	—
Tulane Univ.	14	—	14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Maine																		
Univ. Maine	18	—	18	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Maryland																		
Johns Hopkins	94	52	145	1	29	—	—	—	—	—	—	—	64	—	63	1	8	—
Md. Univ.	67	152	219	—	22	—	—	—	—	—	—	—	20	41	61	—	1	—
Massachusetts																		
Harvard	85	—	84	1	64	—	12	—	12	—	6	—	78	—	76	2	14	—
Lowell Tech.	13	—	13	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Mass. Inst. Tech.	628	—	623	5	441	1	121	—	121	—	52	—	313	—	309	4	79	—
Mass. Univ.	1	12	13	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Northeastern	—	108	106	2	36	—	—	—	—	—	—	—	—	—	—	—	—	—
Worcester	28	—	28	—	8	—	—	—	—	—	1	—	—	—	—	—	—	—
Michigan																		
Detroit Univ.	—	8	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mich. M. & T.	15	—	14	1	11	—	8	—	8	—	—	—	—	—	—	—	—	—
Mich. St. Coll.	59	—	59	—	34	1	—	7	7	—	1	—	27	—	27	—	7	—
Mich. Univ.	304	—	304	—	237	1	3	—	3	—	—	—	148	—	148	—	28	—
Wayne Univ.	233	—	233	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—
Minnesota																		
Univ. Minn.	200	41	239	2	39	—	5	—	5	—	2	—	121	—	121	—	15	—
Mississippi																		
Miss. St. Coll.	13	—	13	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Miss. Univ.	7	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Graduate Engineering Enrollment as of October 4, 1954—*Continued*

Institutions	Number Enrolled in Work for the Master's Degree				Master's Degrees in Eng'g 1953–54		Number Enrolled in Work for Post-Graduate Pre-Doctoral Degrees[1]				Post-Grad. Degrees[1] in Eng'g 1953–54		Number Enrolled in Work for the Doctor's Degree				Doctor's Degrees in Eng'g 1953–54	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Missouri																		
Mo. Mines	33	—	33	—	14	—	—	—	—	—	—	—	4	—	4	—	6	—
Mo. Univ.	22	—	22	—	13	—	—	—	—	—	—	—	4	—	4	—	1	—
St. Louis Univ.	18	138	155	1	4	—	—	—	—	—	—	—	1	—	1	—	—	—
Wash. Univ. (St. L.)	136	—	136	—	31	—	—	—	—	—	—	—	35	—	34	1	2	—
Montana																		
Mont. St. Coll.	16	—	16	—	11	—	—	—	—	—	—	—	1	—	1	—	—	—
Mont. Mines	10	—	10	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Nebraska																		
Nebr. Univ.	15	—	15	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Nevada																		
Univ. Nevada	6	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
New Hampshire																		
New Hamp. Univ.	7	—	7	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
New Jersey																		
Newark	—	722	718	4	111	—	—	—	—	—	—	—	—	—	—	—	—	—
Princeton	70	—	70	—	48	—	—	—	—	—	—	—	36	—	36	—	7	—
Rutgers	19	82	100	1	14	—	—	—	—	—	—	—	—	—	—	—	—	—
Stevens	—	677	673	4	136	—	—	—	—	—	—	—	—	6	6	—	—	—
New Mexico																		
N. Mex. A. & M.	5	27	32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Mex. Univ.	105	—	105	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
New York																		
Alfred	18	—	18	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Brooklyn Poly.	43	1,180	1,217	6	136	—	—	—	—	—	—	—	12	162	174	—	8	—
Clarkson	6	—	6	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
City Coll. of N. Y.	—	323	323	—	37	—	—	—	—	—	—	—	—	—	—	—	—	—
Columbia	407	—	405	2	162	2	—	—	—	—	—	—	128	—	127	1	21	—
Cornell	97	—	96	1	17	—	—	—	—	—	—	—	55	—	55	—	12	1
N. Y. Univ.	81	640	713	8	162	1	—	—	—	—	—	—	9	127	136	—	9	—
Rensselaer	125	61	186	—	61	—	—	—	—	—	—	—	30	11	41	—	2	—

Rochester	9	38	47	—	9	—	—	—	—	—	—	—	1	—	1	—	—	—
Syracuse	15	471	486	—	15	—	—	—	—	—	—	—	22	8	30	—	2	—
Union Coll.	—	61	61	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Webb	11	—	11	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
North Carolina																		
N. C. St. Coll.	71	—	71	—	30	1	—	—	—	—	—	—	12	—	12	—	7	—
North Dakota																		
N. Dak. Univ.	9	—	9	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Dak. Ag. Coll.	6	2	8	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Ohio																		
Case Inst.	72	354	424	3	61	—	—	—	—	—	—	—	40	46	86	—	5	—
Cincinnati	199	198	397	—	3	—	—	—	—	—	—	—	11	—	11	—	5	—
Ohio St. Univ.	129	70	198	1	106	—	—	—	—	—	—	—	69	16	84	1	17	—
Toledo	—	35	35	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Oklahoma																		
Okla. A. & M.	92	104	196	—	33	—	—	—	—	—	—	—	13	—	13	—	4	—
Okla. Univ.	63	—	63	—	20	—	—	—	—	—	—	—	2	—	2	—	1	—
Tulsa	24	35	59	—	19	—	—	—	—	—	—	—	—	—	—	—	—	—
Oregon																		
Oregon State	31	—	30	1	10	—	—	—	—	—	—	—	3	—	3	—	—	—
Pennsylvania																		
Bucknell	3	—	3	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Carnegie	82	115	196	1	55	1	—	—	—	—	—	—	25	—	25	—	25	—
Drexel	270	—	269	1	41	—	—	—	—	—	—	—	—	—	—	—	—	—
Lehigh	114	—	114	—	23	—	—	—	—	—	—	—	47	—	47	—	1	—
Pa. St. Univ.	153	—	152	1	48	—	—	—	—	—	—	—	73	—	71	2	22	—
Pittsburgh	14	348	362	—	58	—	—	—	—	—	—	—	1	36	37	—	3	—
Univ. Pa.	32	602	632	2	67	—	—	—	—	—	—	—	61	—	61	—	3	—
Rhode Island																		
Brown	15	12	26	1	2	—	—	—	—	—	—	—	8	1	9	—	—	—
R. I. Univ.	16	6	22	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
South Carolina																		
Citadel	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Clemson	12	—	12	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
S. C. Univ.	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
South Dakota																		
S. Dak. Mines	10	—	10	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
S. Dak. St. Coll.	3	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tennessee																		
Tenn. Univ.	154	—	154	—	11	—	—	—	—	—	—	—	17	—	17	—	1	—
Vanderbilt	4	—	4	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Texas																		
A. & M. Coll. Tex.	67	—	67	—	24	—	—	—	—	—	—	—	9	—	9	—	3	—
Rice	19	—	19	—	5	—	—	—	—	—	—	—	1	—	1	—	—	—
Southern Meth.	1	447	446	2	14	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Coll. A. & I.	1	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Tech. Coll.	17	—	17	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Univ.	125	—	123	2	46	1	—	—	—	—	—	—	57	—	57	—	7	—
Tex. Western Coll.	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—

Graduate Engineering Enrollment as of October 4, 1954—*Continued*

Institutions	Number Enrolled in Work for the Master's Degree				Master's Degrees n Eng'g 1953–54		Number Enrolled in Work for Post-Graduate Pre-Doctoral Tegrees[1]				Post-Grad. Degrees[1] in Eng'g 1953–54		Number Enrolled in Work for the Doctor's Derree				Doctor's Degrees in Eng'g 1953–54	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Utah																		
Utah Ag. Coll.	16	—	16	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—
Utah Univ.	58	—	58	—	13	—	—	—	—	—	—	—	10	—	10	—	2	—
Virginia																		
Va. Poly.	57	—	57	—	28	—	—	—	—	—	—	—	14	—	14	—	2	—
Va. Univ.	21	106	127	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Washington																		
Wash. St. Coll.	10	—	10	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Wash. Univ.	156	63	217	2	40	1	—	—	—	—	—	—	22	—	22	—	6	—
West Virginia																		
W. Va. Univ.	14	8	22	—	5	1	—	—	—	—	—	—	9	—	9	—	2	—
Wisconsin																		
Marquette	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Wisc.	77	207	284	—	63	—	—	—	—	—	—	—	77	—	77	—	20	—
Wyoming																		
Univ. Wyoming	7	2	9	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
District of Columbia																		
Catholic Univ.	7	156	163	—	7	—	—	—	—	—	—	—	1	9	10	—	—	—
Geo. Wash. Univ.	—	72	72	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Alaska																		
Univ. Alaska	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Total ECPD Schools	8,067	8,769	16,769	67	4,018	13	229	7	236	—	99	—	2,483	796	3,264	15	589	1

[1] Other engineering degrees requiring work beyond the master's degree, but less than the requirements for a doctor's degree.

Do You Know—

► The *Annual Meeting* is at Penn State June 20–24, 1955.

► The office of the Society has now been moved from Evanston to Urbana, Illinois and is functioning with an entirely new staff. The office secretary is Mrs. Naomi Garman, formerly employed in the Department of Theoretical and Applied Mechanics; the membership secretary is Mrs. Louise Chambliss who has had considerable business experience; and the typist is Mrs. Dorothy Sams. Both Mrs. Garman and Mrs. Chambliss were able to spend at least a week in Evanston becoming familiar with their duties under the capable direction of Miss Marion Strohm.

Professor C. E. Watson of Northwestern University is continuing as editor of the *Journal* for several months more. All correspondence pertaining to the *Journal* should continue to be sent to Professor Watson at Northwestern Technological Institute. All other correspondence should be directed to:

Professor W. Leighton Collins, Secretary
American Society for Engineering Education
University of Illinois
Urbana, Illinois

Apologies are extended to all whose activities may have been slowed down due to the change in Secretary, the moving of the office, and the training of a new staff. The new office is functioning and should be about caught up by the time you are reading this, but we do ask you to bear with us during our learning period.

► Professor A. B. Bronwell, our former Secretary, is now President of Worcester Polytechnic Institute, Worcester, Mass. Congratulations and best wishes are most sincerely extended to "President Art" along with a gracious "thank you" for his years of service as Secretary of ASEE. But you are not out of the fold, President Art, and some ASEE committee will soon require your services.

Thanks are also expressed to Mrs. Kathryn Cranford and Mrs. Marion Osterholt for their services as membership secretary and editorial secretary, respectively.

► There is supposed to be a page in each issue of the *Journal* entitled "Candid Comments." It is intended to serve as a means by which the members of the Society may briefly express their opinions in letter form and be heard by the entire membership. In the past there hasn't been much interest in the page. Is it because we lack good ideas? We don't want gripes only, but there should be a means by which constructive ideas of individuals can be presented to the membership as a whole.

► The Final Report of the Committee on Evaluation of Engineering Education will be presented at Penn State at the General Session on Tuesday, June 21. Three sub-committees have been at work on specific portions of the Interim Report and are about ready to submit their drafts to the entire committee for approval for the Final Report.

The General Electric Company has contributed another $10,000 to the ASEE for this project and the Engineering Foundation an additional $3000. The Society sincerely expresses its appreciation to these two organizations for their

generous financial support and growing interest in engineering education.

► "Communications—Experiment and Experience" is the theme of the English Division Summer School—Thursday, June 23 through Saturday, June 25 at Penn State. The program will be of interest to all interested in communication as a fundamental of education and not only to teachers of English.

► The Humanistic-Social Research Project is making very substantial progress. Field workers have visited a large number of colleges throughout the country and Dr. George Gullette, Director of the project, has made a tour of the country to investigate those schools which have been identified by the field workers as having something of exceptional promise. A preliminary report of this Committee's work will be presented at the Annual Meeting in June and the Final Report will appear a year from June. This should shape up into a major contribution of the Society.

► The dates for the Fourth Summer School for Chemical Engineering Teachers at Penn State are June 27–July 2.

► The open Conference on "Thermodynamics in Engineering Education" jointly sponsored by ASEE and the National Science Foundation will be held at Penn State on June 27–29.

► The National Science Foundation has been cooperating with ASEE and financially supporting a number of closed conferences on particular areas of subject matter pertinent to engineering education. Topics covered to date are Mechanics—Physics at New York University, Thermodynamics at Purdue, and Electricity and Magnetism at Lehigh; the physicists also have had a closed conference of their own. The reports of these conferences will be published in the *Journal* as soon as they become available. Open conferences for discussion of these reports are planned by the pertinent sections for the Penn State Annual Meeting. The results of these conferences, along with the report on Evaluation of Engineering Education, really will give us something to think about and work on.

► Have you submitted your nominations for members of the next Executive Board? The December and January issues of the *Journal* contained nomination blanks for this purpose. In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the form and return it to the Secretary's Office in Urbana, Illinois by April 1, 1955.

► When you order your copy of the *Teaching Aids Manual*, or any other publication of the Society, write to the Society office at Urbana and *send your check with the order*. Enclosing the check will eliminate separate billing and reduce the amount of work in the office. Thanks for your cooperation.

► When you receive your copy of the Preliminary Program for the Annual Meeting three cards will accompany it. One is for registration, one for housing and one for special events. The latter requests the listing of the special luncheons expected to be attended (not a final commitment) and the Ladies' Program. Fill out all three and return them as instructed on the cards.

► The Ninth Annual Report on "Trends in the Employment of College and University Graduates in Business and Industry" by Dr. F. S. Endicott of Northwestern University, reveals that 145 well-known business and industrial concerns contemplate employing 18.8 percent more engineers, chemists, and physicists next year than this past year, and only 2.2 percent more non-engineering graduates.

► The next meeting of the Executive Board will be during the meeting of the Southeastern Section at Knoxville, Tennessee, April 14–16.

W. LEIGHTON COLLINS, *Secretary*

The Pennsylvania State University

College of Engineering and Architecture

Most of the facilities of the College of Engineering and Architecture at the Pennsylvania State University will be open for inspection when the American Society for Engineering Education meets on the campus June 20–24.

The annual meetings also coincide with the Centennial Celebration of the University, which was chartered in 1855 as The Farmers' High School of Pennsylvania.

Established as an agricultural college, Penn State did not offer work in engineering for more than 20 years. With Pennsylvania's growth as a great industrial state, there was demand for work in engineering and a program was proposed, but lack of funds delayed the actual beginning of such training until after 1880.

The acceptance in 1863 of the Morrill Land-Grant Act which provided for the teaching of "such branches of learning as are related to agriculture and the mechanic arts" also focused attention on the need for engineering work. In 1881, a department of mechanical arts was established and later that year the department of civil engineering which proved to be the beginning of the College of Engineering and Architecture, was organized. The first degrees in engineering were conferred in 1884.

School Established

As a part of a general reorganization program in 1896, the School of Engineering was established and in another campus-wide reorganization in 1953, this became the College of Engineering and Architecture.

The College of Engineering and Architecture was the first of the colleges at Penn State to attain major proportions and a recognized rank among the leading institutions of the United States and for many years it enrolled a large majority of the students on the campus.

Today the College has more than 2,500 undergraduates enrolled in the curriculums of Aeronautical Engineering, Applied Arts, Architecture, Architectural Engineering, Civil Engineering, Electrical Engineering, Engineering Science, Industrial Engineering, Mechanical Engineering, and Sanitary Engineering.

In addition to the 2,500 undergraduates in the College of Engineering and Architecture, students are enrolled in Chemical Engineering, a curriculum in the College of Chemistry and Physics; in Agricultural Engineering, administered jointly by the College of Agriculture and the College of Engineering and Architecture; and in Ceramics, Fuel Technology, Metallurgy, Mineral Preparation Engineering, Mining Engineering, and Petroleum and Natural Gas Engineering, all curriculums in the College of Mineral Industries.

More than 3,100 Engineers

Thus, a total of 3,189 students are enrolled in these curriculums, which is nearly one-third of the total undergraduate student body of 10,422 and a higher percentage of the 7,746 undergraduate men students on the campus. More than 200 graduate students also are majoring in one of the engineering fields.

The curriculum in Engineering Science, which is attracting attention among educators in the engineering field, was introduced two years ago to train students who wish to enter the fields of research, development and other cerative aspects of engineering. To qualify for enrollment in this honors curriculum, students must have had an average of 2.00 or higher during their freshman year

and must be specially chosen for the curriculum by the faculty of the College.

Other new progress of the college are the two-year terminal curriculums in Electrical Technology and in Drafting and Design Technology. Taught only at the Penn State centers, these programs are designed to prepare the engineering technician for many routine engineering assignments so he may assume a supporting role and become an important auxiliary in the modern engineering team.

The College also has developed a cooperative program in engineering which enables young men enrolled in certain liberal arts colleges to transfer to the College of Engineering and Architecture at the end of their junior year. This plan, requiring five years of college work in most cases, enables a student to attend a small liberal arts college near his home and gain a liberal arts education as well as a degree in one of several engineering curriculums.

Last year, the George Westinghouse Professorship in Engineering Education was established in the College of Engineering and Architecture as a means to evaluate and improve methods used in engineering education.

STUDY TRANSISTORS—Experiments with a point-contact transistor are conducted in the Transistor Laboratory at The Pennsylvania State University.

Extensive Research

Research, as well as instruction, is an important part of the activities of the College and the research program is centered in the Ordnance Research Laboratory and in the Department of Engineering Research.

The Ordnance Research Laboratory was opened in 1945 when the Harvard Underwater Sound Laboratory was moved to Penn State. Laboratory personnel conduct research and development work in mechanics, hydraulics, electronics, and acoustics with the operations directed toward creating and developing underwater equipment for the Bureau of Ordnance, U. S. Navy.

As a part of the Laboratory, the Garfield Thomas Water Tunnel is used for testing designs of propellers, body shapes, and auxiliaries of underwater devices through the use of powered missiles. The tunnel was dedicated in 1949 and is the largest known water tunnel in the world.

The Department of Engineering Research was organized in 1908 as the Engineering Experiment Station.

Since the first research bulletin, concerned with methods for constructing concrete floors, was published in 1910, the Department has published many extensive reports in many technical fields.

Thermal research work has included the investigation of heat and moisture transfer in building and insulating material. Much of this work is conducted in a climatometer built by joint effort with the War Production Board. Here it is possible to simulate all types of weather conditions, including varying humidity conditions and temperatures from—60 degrees to 130 degrees Fahrenheit.

Diesel research work for many years has been an important part of the pro-

MAIN ENGINEERING BUILDING at The Pennsylvania State University.

gram at Penn State and it includes studies of the many phases of operation of Diesel engines with emphasis on fuel injection, combustion, and scavenging. Exhaust energy utilization and the phenomena of finite amplitude pressure waves in engine manifolds and in high pressure lines of pneumatic systems also are under study.

Special problems arising in conjunction with all types of automotive engines, including winterization, all fuel engines, lubrication, and safety devices are studied in the automotive research program.

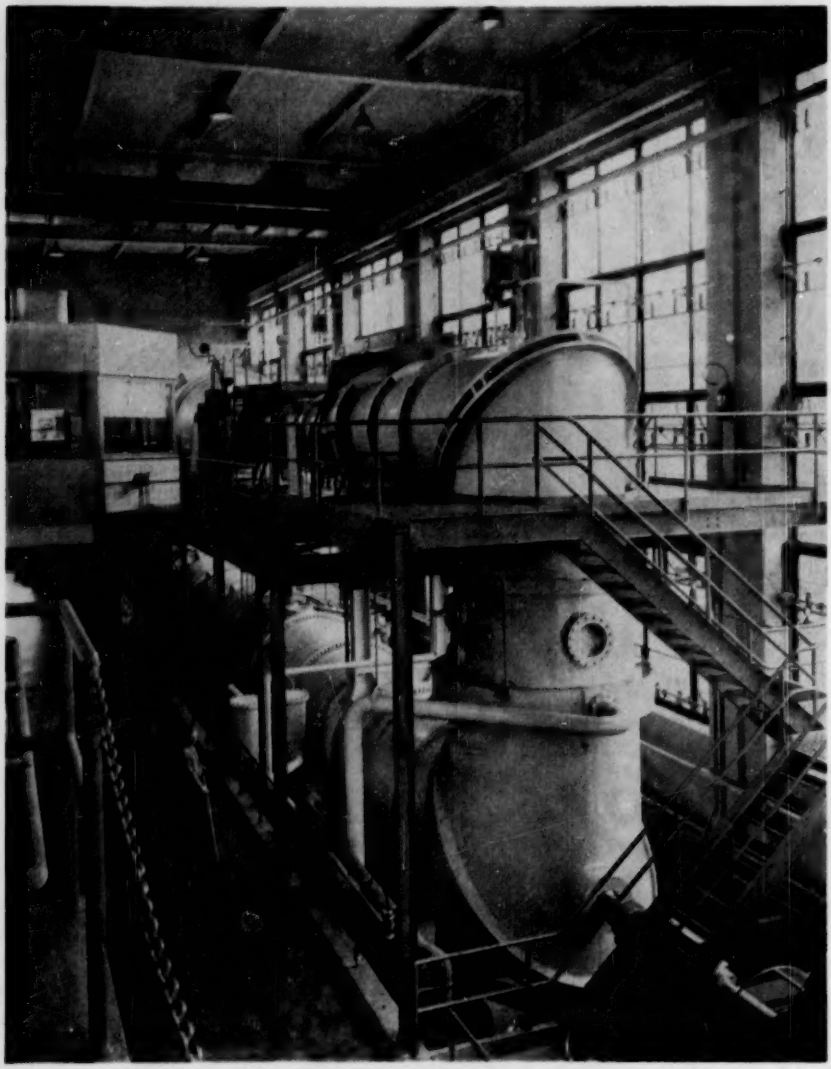
The Ionosphere Research Laboratory has electronic apparatus, field stations, and mobile units with which fundamental

studies of the upper atmosphere and radio wave propagation are studied.

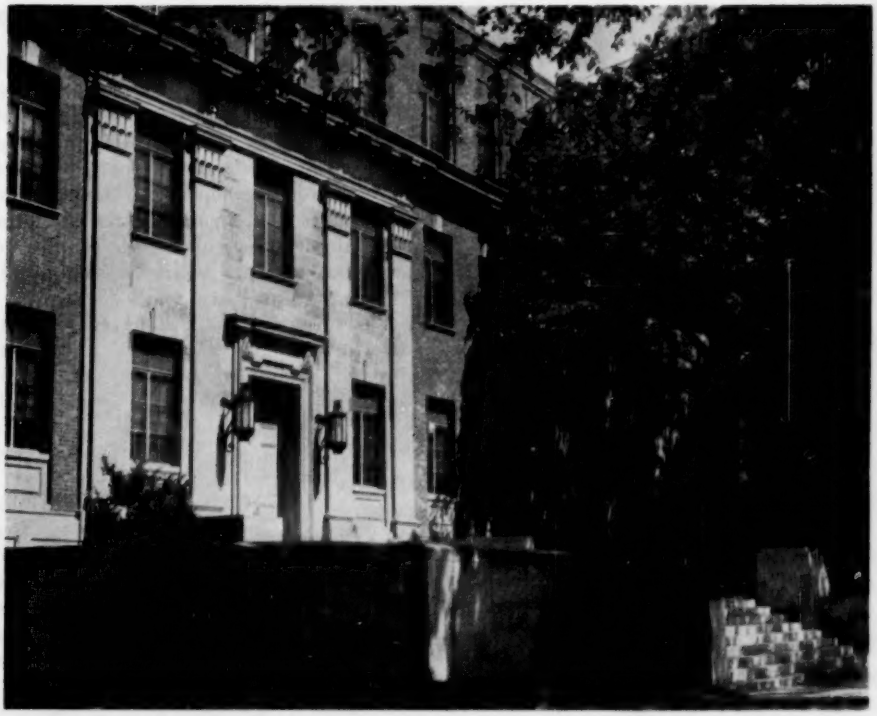
The program in spray research includes fundamental studies on the mechanism of break-up of liquids into aerosols and the influence of various factors on the design and performance of nozzles.

A program in acoustic research is concerned with studies of the vibration characteristics of materials and general problems of noise reduction.

Industries of the Commonwealth, par-



LARGEST WATER TUNNEL—A view of the main tunnel in the Garfield Thomas Water Tunnel building, one of the testing facilities of the Ordnance Research Laboratory at The Pennsylvania State University.



Electrical Engineering Building, The Pennsylvania State University.

ORDNANCE RESEARCH LABORATORY at The Pennsylvania State University provides facilities for important studies for the Navy. Building will be expanded with the addition of a second floor to north and south wings.

ticularly the smaller ones, gain assistance in solving technical problems of an engineering nature through the Industrial Reference Division while a Power Plant Advisory Service furnishes advice on power plant operating and maintenance of the various state institutions.

With the completion of the Nuclear Research Reactor now under construction, Penn State will have facilities for training students in reactor engineering and reactor physics as well as facilities for research in this important field.

The College of Engineering and Architecture also is developing a computer center, which when completed will include an analog computer, a digital computer, and a network analyzer.

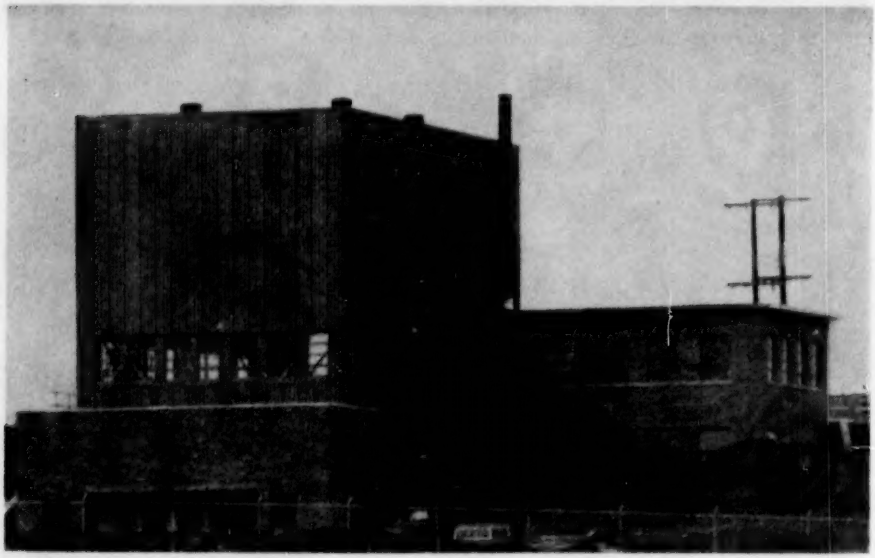
Far-flung Facilities and Services

In addition to the instruction and research program on the campus, the College of Engineering and Architecture through the General Extension Services of the University conducts work in many communities of the State.

Class instruction in engineering and technical subjects is available in eleven off-campus centers at several different levels. Courses and refresher programs for graduate engineers, undergraduate subjects for freshmen and sophomores, the two-year technology programs for the training of engineer technicians, and numerous evening school technical institute curriculums are provided.

The program also includes correspondence instruction and informal instruction through lectures, conferences, demonstrations, workshops, and short courses both on and off the campus. An extensive service in management training is offered to the industries of the State.

The College of Engineering and Architecture, because of its rapid growth after work in engineering was started in 1881, was the first college to have its own building. This structure, completed in 1893, was by far the costliest building constructed since Old Main had been



NUCLEAR RESEARCH REACTOR is now under construction at The Pennsylvania State University and will be ready for operation later this year. "Swimming pool" is located in unit at left, shop facilities in unit to right.

COMPRESSION TEST of sand is made on this strength machine in the modern foundry at The Pennsylvania State University.

completed 30 years earlier and it provided facilities for all activities of the new College. In 1918, fire destroyed this building.

Today, the physical facilities of the College include 12 buildings with 280,000 square feet of floor space on the campus, a civil engineering summer camp about 15 miles from the campus, and field stations for the Ordnance Research Laboratory at Black Moshannon Lake near the campus, at Key West, Fla., and at Newport, R. I.

The program in engineering started with one faculty member in 1881 and today the College of Engineering and Architecture has a faculty and staff, including technical and secretarial personnel, of more than 500. Nearly half of this number is affiliated with the Ordnance Research Laboratory.

Since its establishment in 1896 as a school, the College of Engineering and Architecture has been directed by five deans, all of them nationally known in the field of engineering and those of recent years leaders in the American Society for Engineering Education.

Louis E. Reber was appointed the first dean in 1896 and served until 1907 when John Price Jackson was named. In 1915, Robert L. Sackett succeeded Dean Jackson who had resigned in 1914 and in 1937 upon Dean Sackett's retirement Dr. Harry P. Hammond was named dean. He retired in 1951 at which time Dr. Eric A. Walker assumed the deanship of the College.

The following four articles cover some activities of the General Electric Company and Carnegie Institute of Technology in the field of creative engineering—engineering which represents a contribution to the art, as distinguished from the routine application of known skills. Included is a report of the Teaching Methods Seminar, co-sponsored by A.S.E.E. and the General Electric Company. Twenty-eight instructors from as many engineering colleges spent a week in Schenectady as guests of G. E. and actively participated in techniques used at General Electric to foster the creative process of idea synthesis and analysis as applied to engineering problems.—EDITOR.

The Creative Process*

By E. K. VON FANGE
General Electric Company

The objective of this article is to take away much of the mystery and confusion that may exist with respect to the creative process and to present the factors that comprise successful creative engineering.

The Common Denominator

When eulogizing a notable contributor to progress, it is difficult to say whether he had been creative, or merely ingenious, resourceful, brilliant, imaginative, original, an artful contriver, clever, or all of these. For the same contribution, he may also be labeled fanciful, lucky, farfetched, a good guesser, a daydreamer, or unconventional.

It is the proven or apparent usefulness or quality of the contribution, or some specific condition under which creativity is employed that gives rise to the various shades of meaning offered by the words listed above. And, while these words are useful in semantics, a knowledge of when to use them is unnecessary to understand the creative process. To obtain that understanding, the technique for solving any complex problem will be used, that of dividing the over-all into small portions that can be studied and understood.

A study of these descriptive words indicates that whenever they are used, the persons to whom the words are applied have each done something new or different from what accepted practice would dictate. This holds true whether the men be in research or development, design or product engineering, or in the arts or sciences. It applies equally well for those who are intelligent or moronic, educated or illiterate, married or single. To achieve this, the individual obtained a new combination or application as far as he was concerned. This combination might include an existent device, a mechanism, linkage, or a fundamental law or a just-discovered effect, or a change in attribute such as size, shape, or color.

Creativity, then, is the obtaining of a combination of things or attributes that is new as far as the creator is concerned. As a direct corollary, *any time one does something for the first time, without being shown how, he is, so far as his mental process is concerned, being creative.*

A student, apprentice, or beginner must be creative *if he has not been specifically shown how to accomplish a problem or a task.* For example, initial study of a word problem in any mathematics textbook typically does not reveal the solution or the steps to take to achieve the solution. It is only by careful search of the chapter contents and the process of trial combinations of bits of knowledge that the student arrives at the right combina-

* A revision of a paper presented at the annual meeting of the National Capital Area Section, A.S.E.E., at the Catholic University of America on May 8, 1954.

tion to give the answer. The motivation, though, is through desire to conform, and it ceases, unfortunately, when that has been accomplished.

Because creativity is to place already existing things or attributes into new combinations, it was difficult under the old laws to obtain an unbreakable patent. The competitor merely had to separate the invention into its component parts, find an existing device that contained that component and present this evidence to the court. The court would often rule that, since the individual components were already in existence, the combination of them in the form proposed would be apparent to anyone skilled in the art, and thus, not a valid patent.

By definition, then, all people are or are able to be creative. Their creations, however, can be useful, useless, or even detrimental. For example, pioneers of all ages set out from their homeland with a minimum of equipment, and from the materials of nature created a successful livelihood. The Seabees earned immortal fame by building airstrips and other needs of war under great adversity. Stage productions are often presented on a shoestring budget. Many laboratory experiments are conducted with inadequate equipment. In contrast, individuals are uselessly creative when they worry about imaginary evils, or idly build dream castles in the air, or slowly rationalize themselves into contentment with their past successes or habits.

Creative Expression often Stifled

A child, normally, is quite creative. But the child lacks judgment, and most of his early creative expressions are met with choruses of "don't." Similarly, from grammar school on, emphasis is placed on subjugation to fixed and well-explained text assignments, closely directed laboratory experiments, and well-disciplined study periods. Now, this in itself isn't bad EXCEPT, there is little or no outlet provided for creative expression. As a result, creativity and curiosity dwindle and fall asleep through sheer lack of exercise. It is like building roads and railroads and factories to make use of a wonderful natural harbor, and then becoming so engrossed in this effort that the harbor is forgotten and becomes covered over by drifting sand.

This submergence of creative expression is not due alone to the factors just mentioned. A child who, through physical characteristics inherited by birth, or the child who, by necessity is clothed differently from the remainder of the class or the members of the gang, is a subject of much laughter and derision. After so many object lessons in *conformity* it is rare indeed for creativity not to be stifled.

Eventually, this has the effect of lulling people into the feeling that there is no opportunity for creativity in the solution of their problems and causes them to actually resist changes. (It is necessary to distinguish between this and conformity by choice, which often is desirable in some parts of creative work to efficiently achieve a goal.)

The usual college training also adversely affects creativity. For example, the assignments given in a typical engineering institution might be likened to a foot-bridge swaying across a wide and deep chasm. The problem is the bridge. At the other end of the bridge lies the solution. Strong and sturdy guide rails are formed by the detailed definition, boundary conditions, the applicable formulas or procedures given in the text, etc. As the student goes through his years of education, he is sent across progressively longer bridges, though each is still adequately protected by guard rails, and he has little difficulty. Then, upon graduation, the guard rails are removed and he is told his sheepskin equips him well to start across the bridge. No wonder new engineers may be hesitant and undecided about what to do and how to do it! And no wonder, too, that they learn to use the safely guarded bridges of the conventional in their engineering career and refuse to cross a creative bridge if they see it, simply because it has no guard rails to guide them.

After so many years of doing exercises at the end of a chapter that have only one answer, one approach, and one method, and with all the knowledge required found in the written material immediately preceding, it is not difficult to see why an industry exists today in which any automobile design is all right as long as it keeps the horsepower up front like grandpa's buggy. It must have four wheels, also like grandpa's buggy. It has hinged doors and roll-down windows like the old stagecoaches, even though all of this may not be the most economical or the most practical design. And any refrigerator design is all right as long as it looks like an icebox. Any electric range or gas range is all right as long as it closely resembles the old wood stove. Because of their educational background, many engineers do not even realize that there are many approaches to the solution of any problems for which they may have responsibility, and there are many methods for making each of these approaches do the job required. A recent article said, in effect, that the basic radio circuit has been simplified or perfected to such an extent that no further improvement is to be expected. Someone, some day, will take that as a challenge. He will look for and find a new approach, and a new radio circuit will be created.

Another stifler is that as the standard of living progressively increases, individuals become more self-satisfied with the status quo; and *self-satisfaction or contentment with what one has is the very enemy of creativity.* The individual who first observed, "The dead live in us" summed the situation very nicely. In too many cases progress and growth are impeded because judicial thought processes *depose* instead of *dispose* a creative contribution. And so, even though industry may recognize and create a more efficient automobile or refrigerator or range, customers will not buy if the product is too different.

But perhaps the biggest stifler of useful creativity stems from its definition. It is inherent that the creative "bridge" is initially untested, full of unknowns and possible dangers over its entire span. In many cases it is only through a fierce determination to succeed that a creative process can be successful. It is easy to see why, when reading about notable inventors and others active in the creative process, the great elation they felt when the bridge was finally crossed is so vividly recorded. It is the same thrill that exists in any situation where a human sets himself a challenge, and is victorious over that challenge. It is pathetic that so few have enjoyed this thrill. For these creative bridges can be and have been safely crossed time and time again by the strong-willed few who dared. And anyone can safely dare if he will merely practice.

From the factors listed, it should be evident that *a strong desire to create is essential in the useful creative process.* In engineering, this desire in the past has too often come only when competition or other factors have forced the discarding of the old blueprints or techniques. But even though the strong desire exists, and the individual can easily achieve new combinations, a successful result is not assured. The creator must also be capable of achieving understanding in the area in which he wishes to create.

An individual may exhibit creativity no matter what his level of understanding is. However, the usefulness of the ideas generated is strictly a function(neglecting rare chance) of his understanding of the fundamental concepts involved. This is evidenced by the lower quality of the ideas that occur after an initial study or exposure to a problem. Often these first ideas are found to be inapplicable after additional effort is expended.

However, if a study is made to see how an understanding is achieved, one finds that understanding increases as a function of the number of times he is exposed to a situation (such as learning to drive a car), or the number of times he is called upon to analyze or generalize or use a concept. For example, each time a new theorem is presented in a mathe-

matics course, the student achieves understanding by successively solving more difficult and different problems employing the theorem in their solution. His understanding is increased still more if he takes what he has learned through solving the specific problems and generalizes to find other areas from his background where the application of the theorem would be useful.

In the two previous paragraphs two interrelated statements have been made. First, the usefulness of a new combination is a function of the understanding that produced it; second, understanding increases with the number of times the material to be understood is analyzed, generalized, or otherwise applied or employed. In a typical engineering problem, then, the more possible approaches and methods that can be obtained for evaluation, the better will be the resultant understanding of how best to solve the problem. And as this understanding increases, the additional idea combinations obtained will better accomplish the solution.

The best ideas are often ridiculously simple once they have been thought of, but the embryonic solutions that led to this simple result were really ridiculous, when one looks back and compares. However, they were essential steps in achieving an understanding of how to best solve the problem. It becomes obvious, then, why people who train throughout all their educational experience in the one problem-one solution philosophy experience difficulty in achieving this understanding. Typically, the first method that occurs to them is the only one as far as they are concerned. Unfortunately, it is seldom the best.

Development Factors

From the foregoing, it would appear that heredity affects successful creation in two ways. First, intelligence (which may be defined as the measure of incompleteness with which the whole can be grasped) is the limiting factor in determining the complexity of the situation in which the individual can eventually achieve understanding and create a solution. Second, man's other aptitudes indicate the vocation where he can make the maximum contribution. Training, then, has the objective of overcoming the effects of previous environment so that each man will be as usefully and efficiently productive as his intelligence will permit.

Making the Decision

If a person desires to develop his creative ability, this is a first and essential step. A person may wish to learn how to play the piano. He may go so far as to actually buy or rent a piano. He may send off for self-teaching lessons, and he may doodle with the keys once or twice; but until he actually makes the decision to learn to play; until he actually schedules regular practice time to help him accomplish his objective, he has never really made the decision to learn. And so it is with the creative process. Until one regularly schedules practice and study towards improving his creative productivity, he is rendering nothing but lip-service and the decision to create is lacking. This decision must be made before a person is prepared to meet the challenge of the rocky unknowns of an untried path inherent in the creative process.

Many are attracted by the thought of developing their facility in creative expression, but rapidly lose interest when obstacles are encountered in the reduction of their ideas to usable practicality, especially if it requires learning new knowledge through study or extensive experimentation, or if an understanding requires unfamiliar mathematics to be used. Thus, the willingness to accept the challenge of useful and repetitive creation involves the possession of a high degree of initiative and perseverance. Fortunately, the thrilling sensation obtained from the hunt and at the successful conclusion of a creative endeavor seems to always equal or exceed the effort that was required.

Focus

In an engineering activity it often happens that, even though a person has the strong desire to create, he flits from topic to topic just looking, and because of this he may never get an idea, for he is depending upon an instantaneous "flash of genius" which is a rare occurrence. If he were to settle quickly on just one of those areas, and give it the benefit of deliberate thought, time after time a worthy idea contribution would result.

It is basic to repetitive and successful creation that a person learn to establish quickly a focal point on which to direct his efforts.

Existing Knowledge

Many individuals are able to graduate successfully from school having used only the knowledge found in their textbooks. They seemingly continue unaware of the great reservoir available in libraries, government publications, laboratories, and through regular reading of trade journals. Not only does this deny them many good ideas, but it also leads to needless duplication of effort.

It is also necessary to learn to separate factual knowledge from opinion and assumption. This involves learning not only an equation or formula, for example, but also the assumptions that allow the concept to be expressed so simply. It also requires that he get his knowledge from the best sources. For instance, if another engineer tells him that his idea or design is good, but is already patented, will cost too much, or will never pass Underwriters' tests, he does not accept this as final, but goes to the patent attorney, or manufacturing planner, or Underwriters for the facts. If he is told "We've already tried that and it won't work," he investigates to insure that all conditions were identical. Most of the fundamental advances in progress would not have been made if their creators had listened to the *opinions* offered them.

An engineering project, naturally, cannot be a continuous search for newer and better ways. Unfortunately, after individuals become proficient in creative endeavor, it can become very difficult for them to stop looking and start building. Each better way found improves their understanding and becomes bait to lure them into a little more searching for an even better method. This emphasizes the importance of sound planning to determine when the search must stop in order for construction, testing, etc., to be complete by the due date.

There are two extremes in creative activity. One is to take the first method that gives technical excellence, i.e., a design that will perform satisfactorily the required length of time in the environment imposed. The other extreme is to never stop searching for an even better way. In between lies the road to leadership.

If man were content with his present status, he would have no need for a creative process. He would perform routines, chores, or exercises, and he would exist on what his fathers had handed down to him. It is only when he is not content; when he wants such things as a greater understanding of nature, a greater security against disease, accidents, the elements, and his real or imagined enemies, a greater income or prestige, an improved way of teaching or otherwise serving or helping others that he has this need. It can readily be appreciated that man's desire is quite dependent upon his particular environment. Certain societies, past and present, were so content that no desire existed and no change in culture or techniques were observable for hundreds of years. In fact, a study of history finds the phrase: "the rise and fall of—" used repeatedly. Initially, there is a great awakening, a renaissance, followed by a period of great prosperity and influence. Eventually, a stage of blissful contentment takes hold, an ever-increasing corruption often becomes evident, and the once powerful becomes senile. And this same pattern is all too evident within those segments of industry where precautions against it have

not been taken. Product leaders, blissfully content with their design, wake suddenly to find themselves bankrupt or in a minor competitive position. The same pattern can also be found in individuals who do not take steps to prevent it. They learn and absorb rapidly through schooling and their initial years at a job, eventually becoming content with their level of development and the magnitude of their contribution, and become a stagnant liability rather than an aggressive asset. The Biblical passage, "To him that thinketh he standeth, take heed lest he fall" is quite apropos.

Creative effort, then, arises through man's desire to build a better future, and he learns best what to "build" through a study of the past. Many errors in judgment (and thus misdirected efforts) have been made by not properly investigating the past (or present) to obtain direction. Thus, time for thorough investigation of needs and ways of satisfying them becomes an all-important factor in giving sound basis to judgment in the creative process.

The Creative Process

Man decides to improve

1) Investigates to determine which of many directions will provide the most value for time and money expended.

2) Defines selected direction to make it distinct by specifying the limits or boundaries.

3) Searches in an endeavor to find or ascertain all possible methods of solution.

4) Evaluates each of these to obtain understanding of how best to solve.

5) Executes by completing or performing the solution using the selected method.

6) Interprets by explaining or translating the results to convince others.

The progress of civilization at any period from the time man first existed on the earth is a function of (1) the existing quantity of separate thoughts and things; (2) the intercommunication that was possible between different tribes, peoples, and nations; (3) the permissive atmosphere that existed as his environment. Look, then, at the tremendous opportunities for creative expression today. Each new idea becomes in itself an additional building block to be combined with any of the already existent blocks. Thus, creativity is not a degenerative thing; the patent office need never be closed because everything has been invented. Rather, creativity is a regenerative process; each new contribution permits a whole series of additional combinations or creations.

Sections and Branches

The annual meeting of the **North Midwest Section** of the ASEE was held at Michigan College of M. & T. on October 8–9, 1954. The YET program was brought up for discussion and it was pointed out that such a program could be of great help to the younger teachers.

An invitation was extended to the Section to hold its 1955 meeting at the South Dakota State College early in October, 1955. A motion was made and carried to accept this invitation.

The nominating committee presented the following slate of officers: *Chairman*, L. L. Amidon; *Vice Chairman*, J. W. Howe; *Secretary-Treasurer*, J. O. Storry. It was moved and supported that the secretary be instructed to cast a unanimous ballot for the slate of candidates presented by the nominating committee. Motion carried.

The Creative Engineering Program

By C. FRANK HIX, JR.

General Electric Company

An engineer with creative ability has always been much sought after in industry. Products now found in the market would not be there but for the efforts of men with this ability. Technical knowledge is expanding rapidly. This only seems to increase the need for creative talent in present engineering organizations. It is needed to make the improvements on existing products, to create tomorrow's products, and to develop new manufacturing equipment.

Even though management has ever been on the lookout for men possessing this ability, their discovery in the past has been for the most part happenstance. It has usually been necessary for the creative spark to assert itself under conditions which did not encourage creative work or give opportunity for its practice. Men could be typed according to interest and ability, i.e. sales, research, design, or manufacture. But seldom was the responsibility for a major project requiring broad creative ability and practical design sense ever entrusted to him. Under these circumstances, only exceptional men gained recognition for creative genius, resulting in the intuitive abilities of countless engineers being lost to both industry and society.

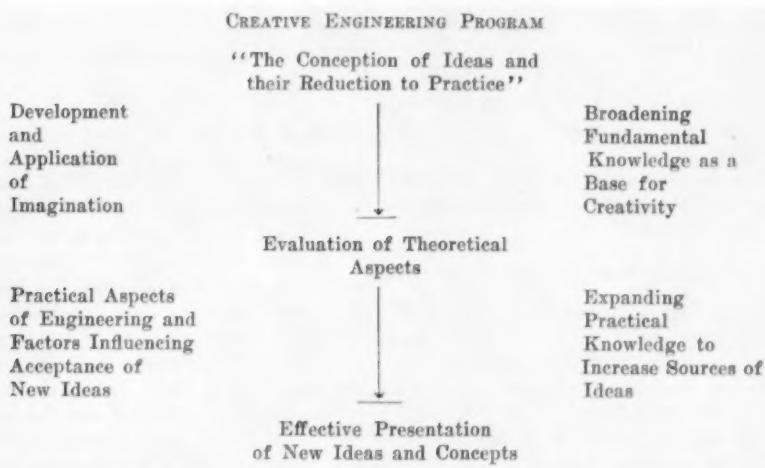
The Creative Engineering Program of the General Electric Company offers the opportunity to young engineers first to develop and then apply their latent creativeness in a permissive atmosphere. The development of this creative ability has at its core the conception of ideas. But the Program training does not stop there, and perhaps a little story will best tell why.

A teacher was well known for his wisdom, and one of his students decided to test him. The student caught a small bird and went to the teacher's home. "I will ask him if the bird in my hand is alive," he thought. "If he says it is, I will crush it; if he says it is dead, I will release it." But when he asked his teacher this question, the wise man said, "The choice is yours."

At each step in the development of an idea, it can die as easily as the bird in the student's hand chiefly because the immediate possessor of it or a person coming into contact with it does not recognize its importance or his influence over it. It is on this point that an industry can become stronger or can stagnate through the value of the one idea that is given or denied. Careers advance or become static to the degree that a person has the ability to recognize progressive thinking and to see that it is applied most effectively. In other words, ideas and sound thinking can be stifled or poorly utilized, or they can be weighed carefully and strengthened to further technical knowledge and human progress.

This, then, is the purpose of the Creative Engineering Program: To increase engineers' ability to gain ideas, to strengthen them on the basis of sound thinking, to utilize them fully, and ultimately to get acceptance for them.

Creative engineering can be stated as the engineering that is performed on a given assignment which represents a contribution to the art as separate from the routine application of known skills. It is not important whether the job is one of development, design, manufacture, or sales. For if an engineer can consistently bring about a new and different practical


CREATIVE ENGINEERING PROGRAM
"The Conception of Ideas and their Reduction to Practice"
Development and Application of Imagination
Broadening Fundamental Knowledge as a Base for Creativity
Evaluation of Theoretical Aspects
Practical Aspects of Engineering and Factors Influencing Acceptance of New Ideas
Expanding Practical Knowledge to Increase Sources of Ideas
Effective Presentation of New Ideas and Concepts

Shown here are the curriculum goals of the Creative Engineering Program

solution to a problem, he can be termed creative. A creative design costs less and performs better in the ways the user values most.

There are four important aspects to developing creative talent. The relationship between three of them can be easily visualized. The use of one's imagination is most important in getting ideas. The base of the reservoir from which one draws his ideas, however, has as its length the familiarity with theoretical fundamentals of engineering, and its width the practical applications of these fundamentals. The depth of the reservoir is the understanding of the significance of this knowledge. Ideas can be taken from this reservoir, sometimes at will, often only after conscientious study, and once or twice in a lifetime as the "flash of genius."

The fourth aspect involved is the manner or approach one takes toward solving a problem and applying the fruits of his creative effort. This approach can be refined to the following four steps: (1) Definition of the Problem; (2) Search for Methods of Solution; (3) Evaluation and Selection of a Method; (4) Details of Solution Evaluation.

A curriculum has been established which encompasses the above four points. It has proved itself in the accomplishing of the goals of the Program.

The C.E.P. curriculum concentrates on the conception of new ideas to solve engineering problems. It does this by the development and application of one's imagination and by increasing fundamental engineering knowledge. Rotating engineering assignments and the homework problems call for the practice and refinement of the material presented and the evaluation of the theoretical aspects. Also, the curriculum bridges the gap from idea to practical use.

Inherent in the Program is a plausible and integrated engineering philosophy that is both instructive and stimulating to the young and inexperienced engineer. The level of technical (or analytical) ability expected of the engineer at the beginning is equivalent to a college degree in general engineering. The wide diversity of college specialties found among the graduates precludes any other assumption. Therefore, by accepting a set of criteria for a creative engineer, i.e. a creative approach to a problem, an active and inquisitive mind, a broad background of information and fundamental knowledge, ability to present ideas and

problem solutions effectively, the initiative to get a job done, and the ability to get along with people, a curriculum has been established to develop and bring out the latent ability of the engineer in each of these areas.

The training consists of three interrelated phases: rotating assignments, class work, and homework.

Rotating Assignment

The training provided during normal working hours consists of a series of organized assignments under the direction of senior engineers acknowledged to possess creative ability. These engineers take special care to develop imagination and skills through discussion and personal example. In so far as possible, the young engineer is given complete responsibility for the development or design of a device so that he may gain early the confidence essential to a productive career. In the course of a year, each young engineer works in four assignment areas.

Class Work

The classes are held once a week, four hours per class, on Company time. The class usually consists of guest lecturers and student discussions. The classes are supervised by recent graduates of the Program. The class supervisors organize the class work and arrange for lecturers and class leaders. These supervisors recognize the problems of the young engineer and through counseling help him derive the most benefit from the training.

The classroom sessions are the nucleus for the technical and creative growth of the members of the Program. Their abilities are developed through practice. Much class time is devoted to the practice and discussion of the known creative techniques. The technical material in mechanical and electrical subjects is given

John Bayles, B.S.E., Tulane, presents new radar antenna tilt drive principle to product department engineers

Preston Hammond, B.S.M.E., Bradley, explains operation of automatic small wire spool changer to class members. (Both devices shown here were developed by 3-man project teams as part of their class effort)

to increase the general understanding of fundamental knowledge. The presentation of a creative approach to new and different engineering problems is molded into a philosophy of engineering.

No idea and no problem solution, no matter how good, is worth a penny until it has been sold to someone. Written and oral presentation, including visual representation of one's thoughts is included all through the class curriculum.

Homework

The organization of one's resources to focus on a problem is the first step tackled in homework problems. Eighty percent of all homework problems are design problems of current interest to the Company's engineering departments. These new and live problems stimulate creative thinking and the "non-habitual" approach. Thus each young engineer develops a creative technique best suited for himself. Solutions to these problems are often of use to the product departments concerned.

The initial contact with these problems is through a one week study with the results presented in an engineering report. Technically, there is no difference in homework problems and those tackled by operating departments other than the magnitude of effort involved, and the extent to which results are carried toward a salable product. By the end of the C.E.P., several larger projects have been tackled, this time in groups of three or four men. Team work is necessary to solve these problems. The last project tackled finds results carried to a point where many manufacturing details are incorporated. This gives the trainee a practical concept of all of the elements that contribute cost to his products.

This, of course, opens the door for creatively reducing product costs.

Selection Process

The applicants for the Creative Engineering Program come from those young engineers taking the Advanced Technical Course. This latter course is primarily an engineering problem course. After one year of participation in the Advanced Technical Course, starting in September, men are selected on the basis of interest in and ability to do creative engineering. This process allows those candidates whose background shows little evidence of creative ability to get special trial assignments in the conception of new ideas and the design of new testing equipment to spark unsuspected talent.

Opportunities for Graduates

Upon completion of this Program, opportunities are opened to the graduates in three major areas. These are: Advance or Development Engineering; Design Engineering; and Manufacturing Engineering. Again in the transfer to an operating department, as in selection for the Program, each man is considered as to his interests and abilities for each opening in the Company that exists at the time of graduation. The Program, while still young, has seen many of its graduates advance into responsible positions and contribute to many of the Company's creative achievements.

The Results Achieved

In the 16 years the Program has been operated, a total of 347 men have graduated from it. The graduates have been of two types. First, a small proportion have possessed a very high degree of inventiveness and have been interested only in the developmental phases of engineering. They thrive on new problems but have little interest in carrying through to a finished product once the method of accomplishing the result is known and proved. Secondly, a majority of the graduates have followed the objectives of the Program more closely. They are design engineers who apply ingenuity at the proper stages of the design problems but who get immense satisfaction from carrying the work through to a finished product ready for delivery to the customer. In industry, the number of opportunities are more prevalent for this latter type.

In both groups there have been many examples of broad individual achievement considering the comparatively short experience of the graduates. Most of them have several patent dockets by the time their rotating assignments are finished and continue in this direction on their more permanent assignments which follow. The number of dockets which are carried through to patents for Program graduates indicates several times the patent productivity of non-program men. An indication of the value of the Program to the General Electric Company is reflected by the demand for graduates which has consistently run many times the number of men available. A number of graduates have received the Coffin Award—the Company's highest award in recognition of outstanding engineering contributions.

The Program has definitely proved itself. Naturally, like most training programs, it has been possible only to provide an introduction to the field of creative engineering. Each graduate has received encouragement to do this type of work, has gained practice in it, and has in some measure "glimpsed the horizon." After graduation, except for departmental supervision and stimulation, he is left on his own to continue his study and development as he rises in professional stature. It is felt that his full potentialities have not yet been realized because of the period of years required for full expression of creative talent. His ultimate worth depends on the further progress he makes towards understanding his own abilities and in receiving continued encouragement to develop these abilities throughout his professional career.

Report of the 1954 American Society for Engineering Education-General Electric Teaching Methods Seminar, August 30 through Sept. 4, 1954

By R. H. BUESCHER

General Electric Company

Almost everywhere you go, you will find the practicing engineer aware of the differences between the college campus and the industrial world. He realizes only too well how his day-to-day learning differs from that absorbed in the engineering schools. The student works to solve the theoretical problems of next week's quiz. The engineer works to solve the practical problems of industry.

A unique approach to the problem of bridging the gap between college and industry is the program of industrial cooperation with colleges—not only with schools in a given area, but through direct nationwide contact with educators. By sharing industrial and institutional teaching techniques and philosophy perhaps we can ultimately close the gap.

This is to report on the latest ASEE-GE endeavor in approaching this problem. The third consecutive teaching methods seminar was presented in Schenectady from August 30 through September 4. This seminar, like the two preceding seminars, was sponsored jointly by the Educational Methods Division of the American Society for Engineering Education and the General Electric Company. Its purpose was to acquaint college instructors with "The Creative Engineering Program at General Electric and to have them actively participate in the creative process of idea synthesis and analysis as applied to engineering problems.

Twenty-eight instructors of electrical, mechanical, chemical, and industrial engineering attended the 1954 seminar. These candidates were selected on the basis of geographical and curricular distributions and the nominations of the various deans of the accredited colleges.

From previous seminars, the objectives of the 1954 seminar had evolved as follows:

1) To present some of the teaching techniques which General Electric has used to advantage in its Advanced Technical Programs.

2) To show one method of application of these teaching techniques to undergraduate collegiate instruction.

3) To provide a medium of free interchange of various techniques presented by the seminar members, in an atmosphere conducive to learning.

Perhaps these objectives and the way in which the seminar tried to meet them can best be described by presenting a sketchy chronological diary of the activities throughout the week. Housing and living accommodations were arranged in one of the fraternity houses on the campus of Union College, thereby providing in a measure some of the informal atmosphere desired to meet the third objective.

The first morning of the seminar contained the only formal portion of the entire week, and this was for only one hour. Words of welcome and explanation of the seminar schedule were presented by Dean B. R. Teare, Vice President of the A.S.E.E., and Messrs. M. M. Boring, A. M. Anderson, and R. H. Buescher, of General Electric. At the conclusions of these presentations, the free invitation to informality was expressed, with later meetings being discussions rather than lectures.

Learning by Doing

One of the techniques which General Electric hoped to present was its use of the philosophy of "learning by doing." Perhaps the best way to teach this technique is to apply the method itself. This the seminar staff decided to do. On Monday morning, the instructors in attendance were asked to work problems given on an entrance examination. These short problems were designed to (a) illustrate the type of quiz used in General Electric's Advanced Technical Programs, and (b) show the need for real understanding rather than superficiality in the solution of engineering problems.

That same afternoon, the philosophy of "learning by doing" was continued in the presentation of another engineering problem. Dr. D. W. Ver Planck, Head of the Department of Mechanical Engineering, Carnegie Institute of Technology, asked the group to consider the following problem: "A given inertia load is to be accelerated at its maximum rate with a given motor. There is the possibility that a simple two-gear system may be employed. Investigate its desirability and in 8 hours report your findings."

This problem was designed to show a way in which "learning by doing" could be used in undergraduate collegiate classes—in this case, Dr. Ver Planck's Engineering Analysis Courses which are presented at Carnegie Institute of Technology in Pittsburgh. The problem, typical of real engineering problems, was "ill-defined" and "open-ended." No qualifying assumptions were forced upon the "student" and no particular results were specified. As work progressed, more facets of the analysis became apparent, important, and eventually explored.

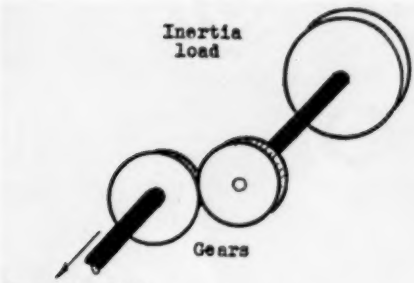
As a follow-up, Dr. Ver Planck reviewed the work of the instructors and presented the solution of the problem in a similar fashion as he would do to his own students at Carnegie Tech.

The next day, Mr. E. K. Von Fange of General Electric's Engineering Education staff presented a typical problem used in GE's Advanced Technical Programs. The problem was to consider, with a view toward improvement, a current model of a radar antenna tilt drive, which was obviously bulky, complicated, and costly. Again the problem was typical of industrial problems in that it was not very well defined and provided the opportunity for a "no holds barred" kind of approach. This kind of problem, although common in industrial practice, was a rather new situation to some of the seminar participants; however, the group soon began to develop many ideas for improvements.

After a few hours of individual and small group study, Mr. Von Fange called the group together to discuss the progress thus far. Six ideas were forthcoming on various ways in which a conical radar beam could be generated. It was interesting to note that as each of these ideas was brought forth, additional people in the group discussed them, evaluated them, and in a measure judged their worth. At this time, Mr. Von Fange introduced another technique used often in General Electric's Advanced Technical Programs—the "brainstorm" session.

Brainstorm Session

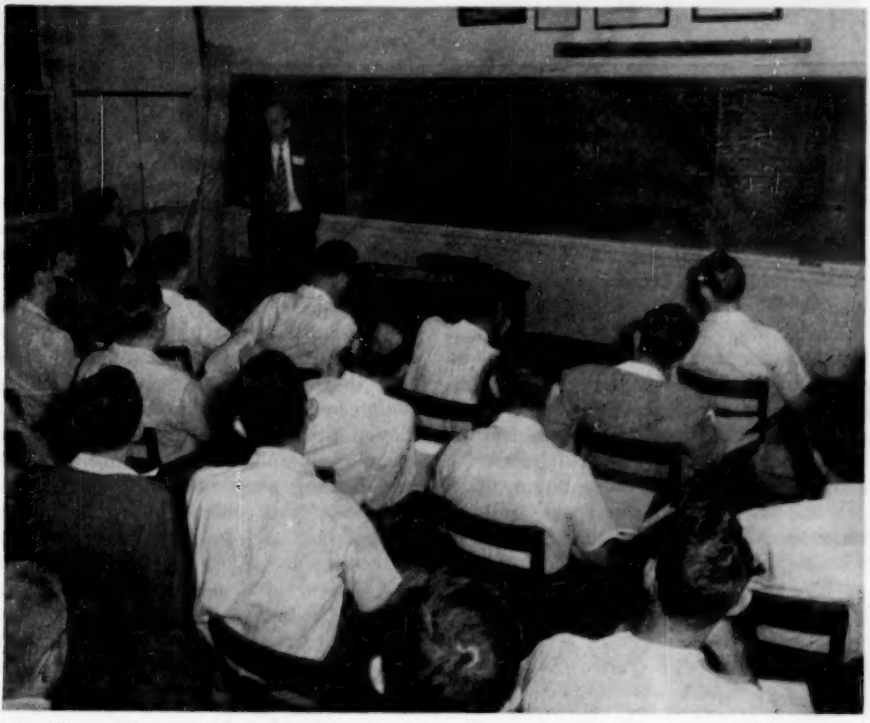
The brainstorm session was described as a discussion in which ideas are brought forth but no attempt made to judge them or to consider them in any fashion, but rather to use them to stimulate further ideas. As two ideas are brought forth,



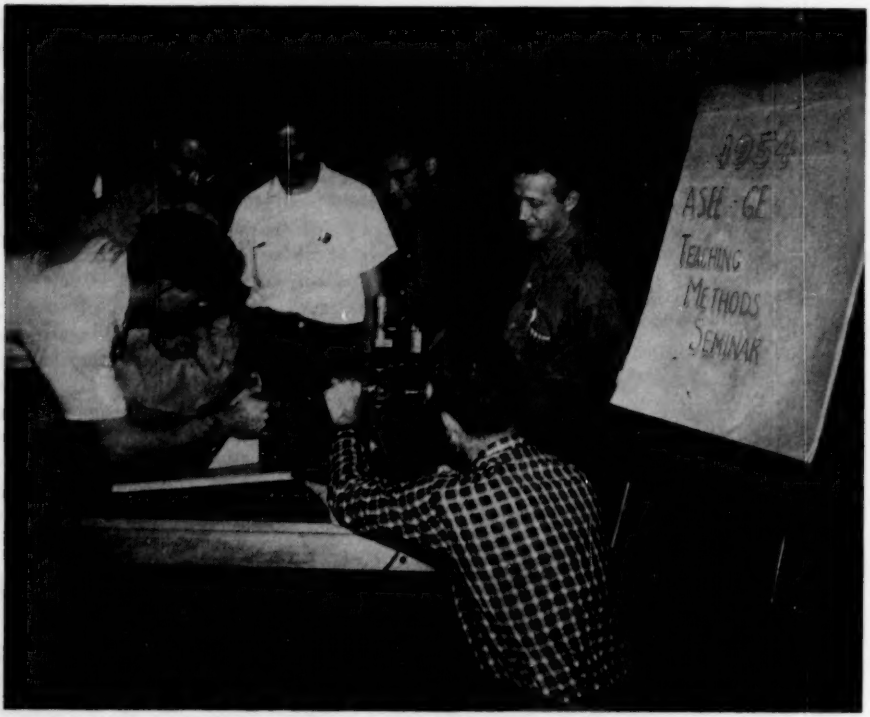
The First Seminar Problem presented by D. W. VerPlanck

perhaps a third will result from the combination, and additional ideas result from the additional combinations. This technique, when applied by the seminar participants, evolved 38 additional ideas in the space of 20 minutes, evidencing the potency of the brainstorm technique.

During the following 15 hours devoted to solving this engineering problem, a good deal of emphasis was placed upon definition of the problem, search for methods, evaluation of the methods, and carry-through on solving the problem. Each of these steps is important in a problem-solving process. It is felt that one or more of these steps is often only superficially considered in collegiate instruction. It was the hope of the seminar staff that the importance of all of the steps in the problem-solving process would be considered and evaluated by the seminar participants. Many of the solutions which evolved from the seminar group working on the problem were



D. W. VerPlanck (Head, Dept. of ME, Carnegie Institute of Technology) discussing the first Seminar problem with the participants



E. K. Von Fange (General Electric Co.) discussing the second Seminar problem with a group of the participants

crystallized enough to merit continued consideration had the seminar been longer.

During the seminar week, additional time was devoted to group discussions of educational techniques brought by various seminar participants. Among those considered was the general problem of instructor education, use of laboratories and projects in the presentation of a problem-solving philosophy, as well as some time devoted to plant tours and a visit to historical points of interest in the area.

The 1954 Teaching Methods Seminar participants worked hard, with a full schedule, but A.S.E.E. and G.E. hope that they returned to their schools filled with continued enthusiasm for their chosen profession, armed with some new techniques which might prove helpful, and holding some memories of new associations with their colleagues in industry.

Engineering Analysis as Training in Ingenuity

By D. W. VER PLANCK

Head, Department of Mechanical Engineering, Carnegie Institute of Technology

The process of inventing or creating a new product or process often is considered to be the antithesis of analysis, and, indeed, this is true if a well defined situation is being treated by means of a well known procedure with which the analyst is thoroughly familiar. However, if one thinks of analysis more broadly as including the whole process by which an engineer copes with his problems and finally reaches decisions, then it is found that analysis requires the exercise of ingenuity and inventiveness in much the same way as does the creation of something new. Whether the engineer is analyzing a complicated situation or is endeavoring to find a new way of doing something he must bring to bear all of the appropriate knowledge, methods, and means which he has at his disposal or can acquire for the purpose. Helping students to learn to do this is the function of courses which we call Engineering Analysis.* In what follows I shall try to show how such a course can help students exercise and develop ingenuity and so help them toward a capacity for creativeness, which certainly depends heavily on ingenuity, if indeed, it is not the same thing.

Our Engineering Analysis courses have as their object training in the art of solving engineering problems, particularly those which are susceptible to some sort of analytic rather than experimental attack. The subject matter of the problems may be anything related to the student's professional field. For example, problems for mechanical engineering seniors may be concerned with such diverse subjects as heat transfer, stress analysis, vibrations, economics, heat pumps, and electro-mechanical servo systems. The course confronts the student with problems completely new to him—ones which he is unlikely to find worked in reference books or ever to have met before—and is devoted to helping the student develop a systematic and professional style for attacking such new and unfamiliar problems. He is taught to ferret out the real problem from a confused situation, to plan how to use what he knows to solve it, to check his work in every reasonable way as he goes along, and finally to draw sound conclusions from what he finds. Each problem requires from six to eight hours of outside work. Class periods are devoted mainly to discussing problems already worked by the students and the principles underlying the solutions. The problem situations are not necessarily very complex, nor is there always much mathematics to be done. The situations do require straight and original thinking and often there are alternative ways of proceeding. There is plenty of opportunity for exercise of ingenuity, particularly in planning which of several approaches may be best, in executing the plan, in devising checks and in interpreting the results of the mathematical solution.

Example of a Problem in Engineering Analysis

To make the foregoing clearer, consider an example. The senior mechanical

* "Teaching Methods in Engineering Analysis," B. R. Teare, Jr., *Journal of Engineering Education*, Vol. 35, June 1945, pp. 599–604.

engineering student is asked to predict from design information how long it will take a fan driven by a direct-connected induction motor to come up to full speed after the motor is energized. The information available includes, besides irrelevant things, the torque-speed curves of the motor and of the fan in graphical or tabulated form, and the moments of inertia of the rotating parts.

After some cogitation the student will realize that information on induction motors recently acquired in his electrical engineering minor course is not going to help him. Neither is what he has learned about fans in his fluid mechanics course of any use. He must find that the fundamental principle that governs the solution of the problem is something learned in elementary dynamics a year or two earlier and which he now must apply by himself, perhaps for the first time really on his own. The idea he needs to express is, of course, that the summation of the torques acting must equal the product of angular acceleration and the combined moment of inertia of the rotating parts.

Reducing this to symbolism, the student might write

$$T_M(\omega) - T_F(\omega) = I\frac{d\omega}{dt}$$

where $T_M(\omega)$ is the torque developed by the motor as a function of speed; $T_F(\omega)$ is the torque required to drive the fan, also a function of speed; I is the combined moment of inertia of the rotating parts; ω is the angular speed; t is the time.

Now comes the question of how to solve this differential equation, and, if the student has just studied graphical and numerical methods, it would be very easy for him. If he has not had such experience, the student must exercise his ingenuity; he must consider the fundamental things he knows about differential equations and then contrive a plan for solving this one. If on the other hand he is familiar with graphical and numerical solutions the problem is not appropriate for the purposes of the course.

A student thinking too hastily can go wrong by working with average values of torque if he uses the average with respect to speed which is easy to find, but, unfortunately, not right for the purpose at hand. A more careful student may decide to solve the equation for the slope $d\omega/dt$, and then step by step calculate the whole curve of speed versus time. In doing this he must decide how small to take the increments of time, and he has opportunity to exercise his ingenuity in arranging the calculations so that they will be easy to perform. Or, he may perhaps devise a semi-graphical procedure for stepping his way along the curve. A student who is possibly more ingenious may decide to separate the variables in his differential equation and find t to reach any speed ω as an area under the curve of $I/(T_M - T_F)$ plotted against ω. In finding the area, there are numerous alternatives open. The student may decide to work analytically using Simpson's rule, or by fitting the curve with an empirical formula; or, he may decide to plot the curve to scale and use a planimeter, or perhaps simply count squares to find the area.

Having found in some way a curve connecting ω and t, the student must consider what it means. If he has worked carefully, he will have found that he cannot determine how long the fan will take to reach full speed for this speed is approached asymptotically. As is the case with so many real problems, he finds long after he thought he had his problem defined, that to get a useful answer, he must change the original question; in this case, perhaps, to "how long will it take the fan to reach 95 per cent of full speed?"

Then the student must assure himself that what he has done is sound. He must study his work to see what assumptions he has made, and how they may effect his result. For instance in the case I have discussed, the student has not taken account of bearing friction torques ex-

plicitly. Are they already accounted for in the torque-speed curves he has used? How about the torque to accelerate the air in the system? Are electrical transients perhaps important? In each of the problems assigned him, the student is taught to study his own work critically by raising such questions as these and then devising ways of answering them.

The student is made to check his work in every way. Dimensional checks and arithmetic checks are obvious. Other kinds of checks are less easy and are a fertile field for exercising ingenuity. In the example cited, a reasonably independent overall check may be had by basing a simple calculation on averages of torque with respect to speed, which, even though inaccurate, serves to give the order of magnitude of the result. An enterprising student may check an analytical result by means of a laboratory measurement of his own devising.

Employ Basic Concepts of Fundamental Engineering Knowledge

By way of generalization, consider what characterizes the problem which I have discussed and the others used in Engineering Analysis. In doing this, it is important to view the problem in relation to the experience of the student, and the circumstances under which he is asked to solve it. First, observe that the problem is not subject to solution by substitution in a formula, nor is it given to the student as an exercise to be done after he sees how someone else attacks a nearly similar situation. Rather, it comes as something entirely new and unheralded, and the student himself needs to select from his total store of fundamental engineering knowledge two basic concepts and adapt them to his purpose. These two concepts are the law for angular acceleration of a rigid body about a fixed axis, and a really basic understanding of the meaning either of a differential equation or of an integral. It is important, considering the knowledge which the student may have at his command, that he be confronted with the possibility of alternative means for solution, none of which he can use without adaptation. As a result, the student has an opportunity to search out what he knows that is pertinent and adapt it to his needs, and being able to do this is the essence of inventiveness or ingenuity. To encourage the student in this direction the instructor, of course, must be very tolerant of the round-about and bungling procedures which students are likely to follow as they first learn to go ahead by themselves.

Finally, contrast such a course in Engineering Analysis with an engineering course in which development of subject matter is the objective. In the subject-matter course the student must master new material or new methods. At such a stage of the student's learning there is, from his point of view, only one sensible way to proceed—to apply what he is being taught. Indeed, if instead of doing this, he exercises his inventive talents by trying to devise some less elegant method of his own, he is likely to be rewarded unkindly by a low grade. A course whose objective is new subject matter cannot reasonably be expected to do much toward encouraging ingenuity, for at this stage of learning, the student can know only one good way to proceed. A course in Engineering Analysis, on the other hand, need have no objective beyond developing the power to deal successfully with new and unfamiliar problems. By confronting the student with interesting and challenging situations which are reasonably within his range of experience, he becomes ingenious in applying what he knows, and, above everything, he attains in this way a real understanding of what he knows. My experience shows that students are enthusiastic about such courses, and that, given half a chance, they will exercise an extraordinary degree of ingenuity.

"And Who Knows Whether You Have Not Come to the Kingdom for Such a Time as This?"*

By W. L. EVERITT

Dean of Engineering, University of Illinois

Vice President of ASEE

A year ago at the combined dinner meeting of the Liberal Arts and Engineering Divisions of the Land-Grant Association, my good friend Harlan Hatcher gave a stimulating talk on "What an Engineer Ought to Know." He summed up his speech at the end by saying "an engineer ought to know just about everything." A logical reply might well be "What the Humanist Ought to Know." Alternately, I might defend the engineer and explain why we are so human and at the same time so realistic that we doubt if we will ever attain his admirable goal.

One point on which engineers are willing to go all the way with our friends in Liberal Arts is the need for developing in our students an adequate facility in communication, both verbal and written, not only among ourselves but also with our fellowmen in all walks of life. I would like to enter a plea for a more human and less mechanistic approach to the teaching of verbal communication.

Students, like other people, are apt to learn more from a model than from critics. I like the vivid and succint language used by an English professor who rode a roller coaster for the first time. Asked by a friend to describe the experience, he said, "You have just had time to recite the prologue to Chaucer's Canterbury Tales—when suddenly all hell breaks loose." Is it not true that the first requirement of effective communication, verbal or written, is to develop in the listener or reader an interest in what the communicator has to say or has written? Cannot more emphasis be given in our rhetoric courses to the importance of developing *interest*? If the student has stopped to think of what appeals to the listener, first and foremost, he will have an incentive to develop both better grammar and better unity and emphasis in his writing and in his speech. It can be made obvious to him that if he uses poor grammar he will not be able to interest educated men in his words.

This approach should also enable us to develop in the freshman a recognition of the need for other studies in the humanities and social sciences, because it should be easy to show him that in order to interest others he must understand the background and culture of his listeners, and this requires continued education in many fields. Too often our students are frightened away from the social and humanistic areas by their teachers of rhetoric. These men and women have one of the greatest opportunities of all to initiate an interest in a broad intellectual outlook. This would also lead to the recognition of the importance of empathy, an appreciation for the viewpoint of others—something all men need

* Talk before Joint Dinner of Liberal Arts and Engineering Divisions, Association of Land-Grant Colleges and Universities, November 16, 1954.

today, and a word which is heard all too seldom.

If, on the other hand, we must stimulate the student by appealing to his selfishness, he can also be made to realize that his own progress will be determined largely by how he interests others in his ideas, and the most important of these "others" are apt to be men of culture, who will judge him by the form as well as the content of what he has to say.

If it is true that communication requires the development of interest on the part of the listener, is it not a paradox that our courses in the art of communication are quite generally considered by students (and not merely by engineering students) to be uninteresting?

But I did not come here tonight to criticize, rather I am here to explore how we may work together. This means that we should be friends. It also means that we must be perfectly frank with each other if we are to achieve real cooperation.

Need for Cooperation

Our need for cooperation is emphasized by our present peril. Peril is not new to the human race. Someone has said that the trouble with each generation is that it hasn't read the minutes of the previous meeting. In history we have many examples of perilous times. Sometimes the intellectual climate has produced statesmen who have led the people out of their troubles to greatness, and at other times such statesmen have been lacking. As an example in our own American history, consider the period of the late Eighteenth Century when our nation was founded. Our constitution was written and adopted and thirteen antagonistic colonies were welded into a nation. Contrast this period of the late Eighteenth Century with the 1850s, when there was a widening chasm between proslavery and antislavery publicists and literary men, and when fanaticism on both sides replaced reason. Lincoln and Lee stand out particularly because of the drabness and mental mediocrity of their associates. When one was defeated and the other was assassinated, there was no one left to provide adequate leadership. In the reconstruction period, statesmen and men of good will were notably lacking or ineffectual.

In spite of criticism and anti-intellectualism, there has probably been no previous era in which so much faith has been placed by the people in education and in educators. Furthermore, while in previous centuries, scientists and engineers generally did not make, and were not expected to make, contributions to the solution of political problems, it is doubtful if people today would accept conclusions unless they were based upon a proper understanding of modern technology.

This places a great responsibility upon all of us. I am sure you are all familiar with the story in the Book of Esther. At that time a whole people were threatened with total destruction, for King Ahasuerus had been persuaded by his Prime Minister Haman to issue an edict, and I quote from the words of the third chapter: "to destroy, to slay and to annihilate all Jews, young and old, women and children in one day, and to plunder their goods." To that people the threat was just as real, just as terrible—probably even more real and terrible than any thermonucleonic bomb is to us. In this emergency, Mordecai presuaded his niece Esther, at peril of her life, to intercede with the king, saying in Esther 4:14, "And who knows whether you have not come to the kingdom for such a time as this?" In times like this I ask the same question of our intellectual leaders—humanists, engineers, scientists, lawyers, political scientists, political practitioners—and most especially of such leaders who are functioning in our educational institutions.

I wish that I could come before you tonight with a well-worked-out and integrated plan which I could believe would solve our problem. Even more, I wish that I could have faith that a committee

or a conference participated in by all our disciplines could produce such a plan. But I have no such hope that we can work out *farseeing* plans to which events will conform. With both the physical and the political world moving as rapidly as they do today, we must work for intellectual flexibility coupled with wisdom rather than for the long-range foresight of the soothsayer.

It has been said that in recent years we do not have a signing off of wars, but only short pauses for enemy identification. Some think this enemy identification is simple, as in each period of history men have thought it simple because they could point to external tribes or nations planning or waging war against them. But can we assume that our enemies are only specific foreign nations or domestic subversive groups? The most dangerous enemies are those who are not recognized, particularly if they are among ourselves. They may include, to list just a few—ignorance, rigidity of thinking, intellectual snobbishness, personal indulgence posing as scholarship, lack of understanding, yes, lack of empathy. Even in a world of uncertainty we can attack these enemies now; we do not have to wait for them to declare war on us. Are we as a group going to be part of the problem, or part of the answer? We cannot be part of the answer if we are indifferent, lazy, or mere handwringers. We must take a positive approach.

First of all, collaboration of all men of good will is now essential. There is no time left for controversies among disciplines or professions. There is no time left for mere crying over our own or others' past mistakes.

This collaboration must be sincere rather than superficial. The integrity of each discipline and vocation must be preserved, while at the same time each must search its soul. In engineering education we are doing this assiduously, as I am sure you in the Liberal Arts are, too. One example of the self-analysis of engineering education is the current study on Evaluation of Engineering Education by a committee of the American Society for Engineering Education under the leadership of Dean Grinter. I hope some of our Liberal Arts friends will take time to read the report and, if they care to, give us criticisms of it.

New Frontiers

It is perhaps trite to say we are on new frontiers; the world has always had new frontiers. It is also commonplace to say that our new frontiers are intellectual rather than geographical. However, for a moment let us consider some of the challenges that a frontier always presents. In the opening of geographical frontiers one can distinguish between the adventurer, the explorer, and the frontiersman. The adventurer is one who is interested primarily in thrills—a dilettante as it were, who thinks only of himself. Such selfish adventurers are common in intellectual frontiers. On the other hand, the explorer is one who goes into new territory and then returns to the world from which he left to tell about it. His explorations are useful if he leaves a record which can be understood. Only a few explorers are needed in each generation, but their contribution is a most important one. On the other hand, the frontiersman is an individual who goes into a territory expecting to stay and make it his own—to become a part of its life. He expects to develop the new territory for the use of mankind and reduce the wilderness to permanent usefulness. Our universities require for their continued existence both explorers and frontiersmen, although the colleges do not have a monopoly on such individuals.

Let us consider some of the characteristics of the frontiersman.

(1) He needs initiative; like the explorer he will also have an urge to explore.

(2) Closely associated with this initiative is resourcefulness—the ability to adapt himself to new situations.

(3) The frontiersman must be versatile. There is no place in his life for juris-

dictional disputes; he has to be carpenter, hunter, stone mason, farmer, and so forth, and so forth. This versatility is needed on the intellectual frontier also.

(4) He must be flexible. New situations continually appear which he cannot foresee.

(5) He must have courage. In this connection he should clearly distinguish between courage and foolhardiness, so he must have good judgment.

(6) He should have common sense. Karl Compton's sister, whom you may know was married to the head of a missionary institution in India, once had an electrician who was wiring the house. She tried to explain to him something that she wanted, and when he did not understand, she said, "Oh, you know what I mean, just use your common sense," to which the artisan replied, "Madam, common sense is a gift of God; I have only a technical training."

(7) He must be cooperative. While the frontiersman must be willing to strike out alone, he has to work with his neighbors because the peril of the frontier calls for joint efforts of protection, both against human enemies and against the forces of nature.

(8) Above all, the frontiersman has to be a builder, a man who knows he is master both of his own fate and that of others, and his eye must be on the future rather than on the past.

What are some of the objectives our individual groups should undertake? First let me address the engineers.

(1) We should develop a much keener historical sense. It is certainly far more important to understand history and its implications than merely to place events in a chronological order.

(2) We should recognize, and try to transcend, the limitations of our own disciplines. We rather properly place great faith in the so-called "engineering method," but we tend to assume that it can provide a solution to all problems. We must recognize that many men (including engineers) often make decisions on the basis of intuition and emotions, and are not always persuaded by logic, particularly mathematical logic, or by arguments which are phrased in unfamiliar terms.

(3) We must attain a deeper understanding and greater participation in our political and economic life.

(4) We must acquire an appreciation for the cultures of other nations of the world with whom we must live on terms of equality and mutual understanding. Because engineers have played such a large part in the development of our American economy, it may be more difficult for us to understand other cultures.

(5) The engineer, who is a man of action, must, at the same time, learn to recognize the values of contemplation and philosophical speculation which are dear to the humanists.

On the other hand, I would like to urge our colleagues in the humanities and social sciences—

(1) To recognize that there is a true culture in both the thirst for knowledge of the physical world and in the desire of the engineer to "employ the forces and materials of nature for the use of mankind."

(2) To recognize that the rate of change in the world of physical sciences is such that time seems to be shrinking and, hence there is a need for a sense of urgency though not of panic.

(3) To accept sincerely, however reluctantly, the need for accelerated development of means of physical defense, and understand why such a large proportion of the efforts of the engineer and scientist must be employed in this direction. Do not think we are happy about this, but your safety as well as our depends upon our working on this at times behind locked doors, so that often we cannot even tell you what we are doing.

(4) To understand sincerely and to assist us in the solution of the very diffi-

cult problem we have in the education of our students. The rapid growth of our body of knowledge and the difficulty of knowing, as Harlan Hatcher suggested, just about everything, makes us always face a choice between the essential and the good.

(5) To recognize that in the physical and engineering sciences, more than in other fields, the highest productivity appears to occur at a relatively early age, and so we cannot delay too long the time at which our men pass from the student to the productive stage.

Common Problems

Common problems for both groups include the necessity of making unselfish and rational judgments as to staff, curricula, and methods necessary to give an education which shall save us from our enemies and, at the same time, preserve those values which are necessary for men to be truly free. In our programs we must continually study what is important; I should say, what is most important, for we may not be able to afford the luxury of giving to our students all that is good, but may have to concentrate on that which is best and in some cases on that which is essential. Having studied searchingly the contributions we and our fellows in other disciplines and vocations can make, we must pool our resources to attempt to bind together the free nations of the world both materially and spiritually. In doing this we must avoid both the Scylla of trying to force on them political and economic concepts and practices that are adapted primarily to our own nation, and the Charybdis of indifference to their need for technical and material aid.

Finally, we must preserve in this country what our carefully-reasoned judgments assure us are the liberties without which our way of life is not worth defending. We must also try to carry behind the Iron Curtain an honest persuasive picture of both the material and the intangible values common to the free world, neither deprecating nor exaggerating the role of the United States as an exemplar of those values.

And who knows but what we have come to the kingdom for such a time and such a task as this?

Sections and Branches

The 1954 annual meeting of the **Rocky Mountain Section** of the ASEE was held May 14–15, 1954, on the campus of the University of Utah, Salt Lake City, Utah.

The Nominating Committee presented the following slate to the members at the business meeting: *Chairman,* D. F. Peterson; *Vice Chairman,* William Parks; *Secretary,* D. N. Zwiep; *Member of Council,* A. Diefendorf. A motion was made, seconded, and carried that the secretary should record a unanimous ballot.

Brigham Young University was invited to participate with the schools currently active in regional activities of the Society. Responding for Brigham Young University, Harvey Fletcher expressed thanks for the invitation, and stated that his school should be ready to participate fully by 1957. D. N. Zwiep, representing Colorado A. and M. College, invited the section to meet at Colorado A. and M. in 1955. The invitation was accepted by unanimous vote. The chairman appointed J. T. Strate, A. L. Gosman, and N. W. Ryan as a committee to recommend (a) a scheme for rotating places of meeting, with Brigham Young University included as a participating school, and (b) a scheme for rotating the office of Member of Council among the participating schools.

Vibration Problems*

By JAMES J. RYAN

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Synopsis

Recent experiences with engineers in the field indicate that problems in vibration have increased in number and complexity. In design, the analysis may anticipate the vibration difficulties by reducing the possible disturbances or by removing resonance from the structures. In operation, from the measurement of the vibrations, methods of correction are often suggested.

The discussion will develop the steps in the teaching procedures, and the type of vibration problems for students in design courses from the elementary to the specialized graduate class.

The approach suggested in this educational survey is that certain things must be unconditionally understood (known). To this background of fact, theoretical and experimental, each step is added depending upon the time available for additional study. Thus the *few* fundamental factors may be so thoroughly impressed upon the student that he can never forget, and he may always start with a basic viewpoint.

Problems of importance in present day design include the old ones on shaft critical speeds, structural resonance, and vibration transmission; and the new ones on shock mounting for impacts, resonance in control systems, effects of damping characteristics on impulses other than sinisoidal, and the present vibration and impact requirements of government specifications.

Introduction

Modern practice in the teaching of *Vibration Problems* is a combination of the instructor's acquaintance with the basic information which the students have had in previous courses, and his understanding of the common problems in vibration encountered by the engineer of the present. When these two elements are brought together they form a useful body of knowledge to be assimilated by the student. Perhaps the only excuse for the study of *Vibration Problems* is the opportunity the student has to re-learn statics, dynamics, strength of materials, basic mathematics, calculus, and differential equations—made possible by this type of application. Thus it may be observed that the ability to solve problems in vibration is not the principal purpose of these courses, but rather the application of the earlier studies in a new and constructive manner.

It is apparently necessary, therefore, for the student to absolutely know the basic ideas involved in simple *Vibration Problems*—and to be able to develop the solutions without recourse to notes or textbooks. The physical tie between the vibration phenomena and the mathematical interpretation should be thoroughly understood. Thus the student has a definite picture of the conditions of vibration, and the mathematical equivalents which describe the motion. Any of us can write down the equations of equilibrium involved in vibration problems, but the most important function in teaching is

* Presented at the Summer School, Machine Design and Manufacturing Sub-Division, American Society for Engineering Education, University of Illinois, Navy Pier, Chicago, Illinois, June 23, 1954.

for the student to absolutely understand the physical conditions that are displayed by these equations. The difference between knowing and memorizing must be discerned.

The next step, in the study of *Vibration Problems,* is the procedure by which the development progresses from simple motions to more complex ones. This is the coordination, through definition, of the phenomena observed and the mathematical analysis. The third step involves the solution of a number of problems which are representative of both the elementary and the complex vibrations, to obtain some degree of skill and familiarity. The fourth step is the study of analogies, and of equivalent systems which may be useful in repetitive calculations for industrial studies.

At the present time, however, the study of *Vibration Problems* has assumed a more important nature due to government requirements, which are concerned with the industrial problems of fatigue and the malfunctions of instrumentation. Requirements of resistance to high impact, improved control at critical speeds, and the effect of various impulses other than simple harmonic require the student to have a very basic knowledge of the interpretation of simple vibration phenomena.

Teaching Procedures

The teaching procedures, with adequate textbook and lecture support, require that the student be able to develop by himself, without references, the basic equations that are involved in the fundamentals of vibration. Thus each problem is worked out by first developing the equations for the conditions of the problem, and then, when supplied with representative data, numerical solutions are made for the required information. This approach may be rather difficult for students who are in the embryo process of learning how to analyze a problem. It is also hard on teachers, since they must know how to develop the steps and solve the problems—not only the immediate ones, but all the variations which are suggested by the students in their intimate acquaintance with these elementary concepts. This teaching philosophy is based upon the concept that it is better to absolutely know a little than to grope hesitatingly through a mass of information which can only be assimilated by an intimate knowledge.

In the normal study of *Vibration Problems* there are only a few elements which must be absolutely known. These are the equivalence of forces in motion, the effect of the damping factor, the phenomena under critical conditions which change the angles of lag, the magnification factors of the amplitudes of motion above and below the critical speeds, the concept of vibration transmission and absorption, the process of balancing, the test methods for determining natural frequencies, and the use of instruments in the measurement of vibration.

To illustrate that it is easy for students to work out *Vibration Problems* without understanding the mechanics involved, a test was given to a graduate group quite well along in the vibrations course. They were told that in coming to work that morning I bumped the car ahead severely on stopping at an intersection. The bumpers of the car locked and due to the impact, resonant vibration occurred. Knowing the weight of the cars and the spring constants of the bumpers, I suggested they calculate the natural frequency at which the cars vibrated. It was very disappointing to find that no one in this large advanced class was able to correlate the facts of life with the necessary analysis. Thus it behooves us as teachers to teach the fundamental elements of vibration, and to supply practical problems for a better understanding of the mechanics and mathematics involved.

Laboratory Models

In our vibration laboratory are a number of operating models which are used to supplement the student's interest and understanding of the somewhat complex motions under study. The students are often given the physical factors related

to these models, and asked to make vibration calculations based upon the physical dimensions. Tests are then made of the actual operation of the models, and the results of the calculations and the measurements are compared.

The several balancing machines in the laboratory are sometimes used to balance high speed equipment in the area. The actual procedure of balancing of these machines is often observed by the students.

The sound film, "The Mechanics of Vibration" was produced in the Machine Design Laboratory for the purpose of demonstrating the basic elements of vibration, since it is difficult to maintain the models in satisfactory operation. Copies of this film are available at the University of Minnesota. It might be of interest to show this film at the conclusion of the discussion.

Outline of Advanced Vibration Material

The present requirements of industry have stepped up the knowledge required by students in solving *Vibration Problems.* The following list is a sequence of topics based on the actual needs of industry, beginning with the more elementary problems and continuing to the most complex:

1. Free vibration observed in critical speeds and balancing.
2. Damped vibration of instruments on shock mounts.
3. Shake table analysis of natural frequencies and fatigue failures.
4. The determination of torsional critical speeds.
5. Use of instruments in the measurement of vibration.
6. Determination of the effect of G-loadings on equipment.
7. Interpretation of displacement, velocity, and acceleration measurements.
8. The analysis of simple harmonic, square and triangular impulses, and applications to impact.

The purpose of *Vibration Problems* is to illustrate the lectures and textbook material with applications in the solution of normal vibration difficulties.

References

There are a great number of textbooks available with reference material to be given to students in vibration courses. Many teachers prefer to use the problems outlined in textbooks. However, the lack of mental stimuli is often encountered in solving these problems, and sometimes the exercise consists of mere substitution. It is usually more profitable to make up problems based on the immediate discussion and student interest. Sometimes these go beyond the ability of both the students and the teacher, but the attempt is made to tie the information together in an understandable manner.

On the job information is easily gleaned from textbooks and technical papers, and it is quite convenient for the engineer to look up the required vibration equation or a problem that is similar for comparative examination. However, in the average case, an adequate similarity does not exist, and the basic knowledge of the mechanics and mathematics results not only in a solution but also in a much better understanding of the problem.

Conclusions

In summary, it might be stated that the study of *Vibration Problems* is basically for the purpose of understanding the application of mechanics and mathematics to practical problems. This can best be accomplished by a fundamental understanding of the development of the equations which express, in understandable language, the phenomena involved. Not only is this approach useful in the elementary studies of undergraduate courses, but also for advanced graduate studies in the theory of vibrations.

A thorough understanding, even though at various levels, contributes to the effective analysis of *Vibration Problems* in the field, and makes more valuable the work and the resulting satisfaction of the practicing engineer.

How Should Exams Be Graded?

By R. L. SANKS

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How should exams be graded? This question can hardly be answered until we define the aims of education and the role of examinations in the promotion of those aims. Certainly no one would deny that these aims are training in reasoning, responsibility, theoretical and applied mechanics, and general information. Examinations, even among graduate students, are almost indispensable as teaching aids, and as such, they should be designed and administered so that the above aims are not only measured but actually taught. Some instructors see in an examination only a device to separate the A's from the C's, and, like the poor, these will always be with us. But happily most instructors realize that examinations are more than mere proving grounds, that they can provide instruction as well, and that the latter function is of much greater importance than the former.

Instruction by Examination

If examinations are to be used as educational aids, they should be given at frequent intervals; one midterm and one final seems hardly sufficient unless supplemented by several shorter quizzes. In "problems" courses of two or more credit hours, the lecture time lost in three one-hour examinations during the quarter is more than balanced by the benefits accruing from the exams.

Theory and—to some extent—reasoning can be taught by making the exam problems comprehensive and by making many of them difficult and of a somewhat new and different nature from the problems assigned for homework. Students cannot work such problems by rote and must of necessity understand the underlying theory to even begin an attack.

Training students in responsibility is of utmost importance. There appears to be a general decline in responsibility and self-reliance. Specific evidence is not hard to come by: soaring juvenile delinquency, the world-wide movement towards the welfare state where everyone —worker or drone—will receive nearly equal benefits, the carping of pseudo-psychologists who indoctrinate us with the belief that society is to blame for our shortcomings. When irresponsibility is being excused and even condoned, certainly we should be vigilant in this phase of the educational program. I can safely leave it to your imagination to picture the chaos that would follow a general abandonment of professional responsibility by engineers. Who would condone a consulting engineer who has designed a failure and excuses himself by saying, "But my theory was correct. I only forgot to divide by two."?

There seems to be a widespread misconception in the minds of students to the effect that "someone" will always check their computations, and more often than not I have found that students have little respect for arithmetic. It is true that occasionally the most important computations are checked, but it has been my experience and observation supported by that of almost all engineers of my acquaintance that nearly all calculations are not formally checked and that the engineer must stand alone in his responsibility for them. When shall he begin to

learn his responsibilities? Shall we nurture him through school, giving him part credit and an implied pat on the back for getting his theory correct but his answers wrong? Shall we let him unsuspectingly enter industry fatuous in his belief that if his approach is correct naught else matters? And when his rude awakening comes and he learns that industry expects only correct answers, will he rightly blame our educational myopia for sending him unprepared into the world?

I submit that the time to learn the responsibility of accuracy is in grade school and all through high school and college students should expect to be graded on the basis of their results. Lacking control over grade school and high school examinations we can still accomplish a great deal in college. Even though accuracy is only one phase of responsibility, still it is very important. Of course, correct answers alone are not significant; all the arithmetic, mechanics, and theory that lead to the answer must be correct also. Certainly no credit is due a student who, by a series of fantastic blunders or compensating mistakes, stumbles onto the right answer quite by chance.

Grading on Answers

It should be self-evident that if exams are to be graded on answer (i.e., correct theory, application, and arithmetic leading to correct answer), the exams must be designed with that in mind. No thinking person would advocate so grading a long, difficult, and involved exam consisting of a single problem. Anyone might make an occasional mistake; so if we wish to eliminate the element of chance, we must make up exams consisting of several problems with each problem subdivided into several parts. With care and intelligence we can make such exams as difficult, comprehensive, and as illustrative of basic theory as desired, and it can be done in such a way that one early mistake does not imperil the whole exam or even the entire problem. Thus the student is not damned, but only justly penalized, for making a mistake. If many exam problems, so subdivided, are given, the student has just as good a statistical chance to make a good grade as he would have under any other system.

The grading must also be tailored to the new system. A test score of 50 per cent under this system might compare favorably with one of 90 per cent under some other grading method. Each instructor must fit his grading to the difficulty of the exams, and therefore, there will be no more low grades under the new system than under any other.

I, too, once felt this system would be unfair and that grades based upon it would not be truly indicative. Much thought and discussion with practicing engineers and industrialists convinced me that accuracy was important enough to justify a trial. Three years of experimentation has convinced me that it is fair and equitable, that it results in significant improvements in students' accuracy, and that as an indicator of student ability it is as good as any other system of grading.

In order to test the idea that exams graded by this system are indicative, one class became a "guinea-pig." The course was Indeterminate Structural Analysis and the subject matter was Moment-Area, Virtual Work, and Moment Distribution applied to find deflections, moments, and reactions of simple to fairly complex structures—a difficult, hard-to-understand, theoretical course in mechanics. Exams were designed so that they could be and were graded by answer only and also by half credit for correct theory. There were six weekly quizzes of one problem each and five problems in the final exam. All problems consisted of two or more parts, the answers of each usually independent of the other.

Fig. 1 shows the percentile scores as obtained from each system of grading. Note that the correlation is excellent except for students 1, 2, and 10. The final grades appear to be based on the grading system of half credit for theory. Actually

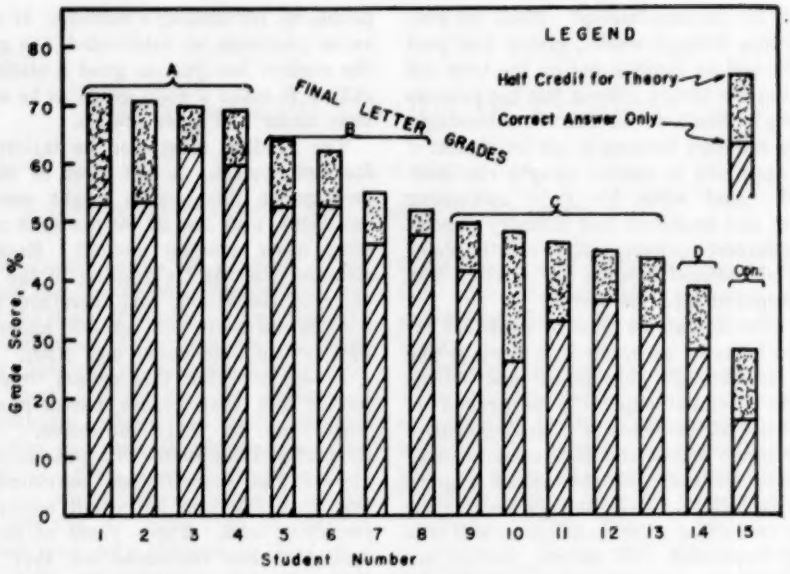

FIG. 1. Correlation between two systems of grading

two sets of grades were made and where any discrepancy occurred (as with students 1, 2, and 10) the student was given the higher grade, largely because the course was so difficult and the instructor so softhearted. But there is no reason to suppose that students were given the most appropriate grade; grades could have been based on answer only (in which case students 1 and 2 would have received "B"s and student 10, a "D") with fully as much justification.

Criticism

It was to be expected that such a system of grading would be roundly criticized, especially by the students. Most students resent this system at their first contact with it. Some have denounced it bitterly with fire in their eyes and, no doubt, murder in their hearts, but those same students have voiced their complete approval of it after they have had a quarter's experience with it. Many have told me that they feel it is the *only* way to grade and that it should be universal.* However distasteful it may be, students are unanimous in feeling that this grading system is good for them, improves their accuracy, makes them more mature, and impresses upon them an appreciation of responsibility.

There are several points of criticism usually raised indignantly by other instructors and by students. These and the answers to them follow.

It is unfair! No one has ever devised a test that is perfectly fair; that is, one that will give a true measure of the student's knowledge and ability. Fairness, then, must be considered a relative term.

If many problems are given so that the grade does not depend upon a chance error, this system is as fair as any. If a student consistently makes arithmetical mistakes scoring zero on all the tests, he has an ingrained sense of inaccuracy and

* This is not "apple-polishing." Student opinions are not quoted if voiced before final grades are given and before all courses with the instructor are completed.

would be as worthless in industry as he is as a student.

Perhaps we should not be so greatly concerned with fairness anyway. Our main purpose is to educate future engineers. Grades are not of primary importance, for no one has ever shown that there is a perfect correlation between grades and success or ability as an engineer. It is unfortunate that they have received attention far out of their true value in educational society.

It emphasizes arithmetic and de-emphasizes theory! On the contrary, nothing could be farther from the truth. It must be obvious that no problem can be correctly worked unless the theory is also correct. Furthermore, theory is emphasized even more than it is under a different grading system for two reasons. First, there is no room at all for muddy thinking. If part credit is given for theory, a student can get some credit if a part of his theory is wrong. However, under the proposed system, he gets no cerdit at all; so theory is therefore emphasized to such extent that all of it must be correct. Second, the student must give a good deal of attention to accuracy; so because his mind is partially diverted, it is mandatory that he know his theory even better than would be necessary under another system.

It should be noted that, under this system, students do not often make arithmetical mistakes. Ordinarily, arithmetical blunders account for about 10 per cent of the mistakes made. The students are, of course, very careful with arithmetic; so their mistakes are primarily those of application of theory.

The pressure in a test is not found in industry where calculations can always be checked! The implication is that it is manifestly unfair to expect accuracy under the "artificial" conditions of a test, and that in industry these conditions of extreme pressure do not exist. This cry of anguish comes only from the inexperienced. What *practicing* engineer has never worked at top speed for many hours and even days or weeks to meet a deadline? True, the tempo of the test may not be duplicated, but that is more than compensated for by the length of time involved. It is much more difficult to avoid a mistake over, say, a two-day period than it is over a two-hour period.

Although much engineering work is checked as a matter of course, probably most of it is not. And, more often than not, the engineer must check his own work, and this the student can do in his exams.

This grading system penalizes students with little native ability in accuracy! Accuracy is not an inbred ability; it is a habit. Basically it is a by-product of complete concentration. It is essentially carefulness and craftsmanship. It can be learned like any other skill, and if not practiced constantly, it can be lost. There is no such thing as a native ability in accuracy. If students are forced to learn accuracy, they will do so, and their employers will be vastly more satisfied with their services.

Conclusions

The most important conclusions to be drawn from this discussion are as follows:

1. A grading system based upon no credit for inaccuracies is as fair and equitable a yardstick as any other for determining a student's grade.

2. To be fair and indicative, both the examination problems and the grading standards must be tailored to fit the grading system.

3. Such a grading system emphasizes correct theory while placing a premium on accuracy.

4. The student learns to be responsible for his work and acquires an appreciation of the obligations of the trust placed in him by his employer.

5. Students are trained in carefulness, accuracy, and craftsmanship.

6. Industry will be greatly benefited by acquiring young engineers with the training in responsibility which can only be offered in a system of grading based on no credit for incorrect work.

Stress the Fundamentals—Applied

By DAVID I. COOK

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The ever expanding field of engineering and the resulting trend to specialization subjects us to new responsibilities as teachers. It is our obligation to place before the student those things which we believe will be of most value to him in the profession in years hence. If we had the gift of prophesy and could say, for example, "John Smith, you will be designing surface controls for rocket ships in 1970," a program of studies could be tailormade for each particular student. Unfortunately such is not the case, and we know that a high percentage of the information supplied the student will never be used. We will be shirking our duty if we fail to scrutinize continually the subject matter in our courses, discarding the obsolete, retaining the unchangeable, and adding the new, to keep abreast of recent developments.

New developments in the field should be presented to the student to promote his interest in the subject matter and keep the course "alive." Considerable care should be exercised in such presentation, however, so that details of the development do not obscure the underlying physical principles involved. For each new development will in time become obsoleted by one more recent. Only the principles will remain unchanged. These underlying principles or engineering fundamentals should, therefore, be emphasized above new and more detailed or specialized material.

Every course we offer contains certain elements which can be considered as being fundamental to the subject. In engineering drawing we teach students to represent three-dimensional objects on two dimensional paper. Fundamental to this subject are the orthographic view, the pictorial view, geometric constructions, and elemental shapes. Recent developments in simplified drafting, new drawing and drafting room standards being completed, and a unification between United States and Great Britain of screw threads and classes of fit, provide ample opportunity to introduce new material in engineering drawing courses.

There is danger that with this wealth of new subject matter, which is of particular interest to the instructor, the principles of orthographic projection will be slighted. What good are simplified thread symbols which appear on an oblique view, if the view itself cannot be drawn?

In descriptive geometry we teach the student to find the intersection of surfaces and to show views of surfaces in specified directions. For simplicity, it is common practice to represent such surfaces by triangles. If we give a problem in which an odd shaped bracket or clip is to be represented, a surprisingly small number of students will recognize the principles of descriptive geometry involved. Most of them will be unable to proceed directly with the solution without some coaching. Here is evidence that between the theoretical principle and the practical application is a gap that should be cause for concern.

In engineering statics we teach students to calculate the forces present in engineering structures and machines. The fundamental equations of statics are easily explained and easily understood by the student. The mathematical relations commonly used in statics are relatively simple. Difficulty in the subject arises, as

in the case of descriptive geometry, in applying the theoretical relations to a practical problem.

In engineering kinematics and mechanism we teach the student to analyze the motion of a machine, determining velocities and accelerations at different points. But if we go a step further and ask for the forces on the crank pin and cross head, he will have difficulty in finding them. There is a gap between the theoretical constructions and the actual forces acting, which is a pitfall for many students.

An engineering student taking a course in differential equations will find the majority of problems consisting of a mathematical relation which is to be changed, using derived relations and algebra, into a form which can be integrated, the integration then being performed by the use of tables. The student will have little difficulty in solving most problems. If, however, the problem is to find the period of oscillation of a weight supported by a spring, he will, in many cases, be unable to set up the differential equation for the motion.

Must Teach Fundamentals in an Applied Form

The point I wish to emphasize is this. We teach the fundamentals to a student, but if we expect him to apply them, we must teach them in an applied form. Engineering is an *applied* science. The majority of our graduates will be required to solve applied problems, and our teaching should be for the majority.

One summer during a period of employment in industry, I recall several instances in which the fundamentals of mechanics were overlooked in an attempt to solve a practical problem. In one case an oscillating cylinder, operating as a shaker, was used to put a certain type of finish on small parts. The resulting vibrations carried through the floor of the building to sensitive instruments and precision machinery. It was proposed to add springs between the end of shaker and the bench top to "counteract the inertia of the cylinder at the end of its stroke." The effect of adding the springs would have been to transfer the force from a mounting bracket attached to the table, to a spring attached to the table. Failure to consider the table as the body which transferred vibrations to the floor and to consider the forces acting on both ends of the spring, constituted a violation of a fundamental principle of mechanics. Mounting two units in tandem so that opposing inertia effects would counterbalance each other finally solved the problem.

In another case a circular recess in a machine part was found to be stepped instead of flat as specified. The defect was believed to be caused by a dull cutting tool or worn bearings. The possibility of a deflection of the work support was overlooked entirely. One of the fundamentals of strength of materials, namely, that bodies deform under load, was not firmly established in an applied form in the mind of the person in charge of the operation. Strengthening the work support solved the problem.

This question naturally arises. How can we present course material to teach the fundamentals in an applied form? My answer is this. Review a given course and select the topics that may be considered fundamental to the subject. The process can be simplified by preparing an outline and carefully evaluating each topic as to permanent worth to the student and the amount of time it should receive. Select a textbook which contains many problems of a practical nature and finally, illustrate every principle presented in class by means of a practical application.

Our objective is to train young men to become engineers, practical men, who must learn to think along practical lines in an ever changing, rapidly expanding field, where the fundamentals alone remain unchanged. In order to provide a sound basis for practical reasoning, let us stress the fundamentals. In order to train the student to relate a basic physical law with a practical problem, let us stress the fundamentals—applied.

Teaching Tips

Conference Method in Laboratory Courses

By JOHN E. GIBSON

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One of the most difficult problems to solve in a laboratory course which must cover certain specified material is that of getting the students to efficiently use their time in the laboratory. One attempt at solving this problem is to give a detailed pre-lab lecture that points out all of the pitfalls and difficulties which may be encountered. Presumably this insures that the required amount of work will be accomplished in the allotted time, but it certainly is spoon-feeding with a vengeance since the lab is usually the only place where the student is asked to exercise his initiatitve.

Another common solution is to pass out mimeographed material which covers the laboratory exercise in detail and which is in addition to the normal laboratory or recitation text asignment. Usually the student still walks into the laboratory cold. Even the threat of a short quiz on the reading material before the experiment only causes a few minutes of cramming before the quiz.

A plan has been evolved which encourages the student's initiative and at the same time permits completing the assigned material. No doubt similar methods have previously been used but since it is sound pedagogically and in addition actually works, perhaps it deserves to be noted.

The laboratory group is set up with a "group leader," an assignment which rotates from man to man. The "group-leader" plan has long been recognized as sound psychology as well as good experience for the students. However, in practice it sometimes fails due to the inexperience or timidity of the weak men in the group. The quicker men may resent having a slower man giving directions. Even if the slow man is conscientious and has prepared for his assignment (which is not always the case) the better men may argue with his decisions since they are not sure that he knows what he is talking about. Further, the instructor, if he is going to utilize the group leaders at all, will not give as detailed a lecture as he would otherwise. Thus the risk is run of the entire exercise failing.

These shortcomings may be eliminated by having the group leader meet with the laboratory instructor previous to the laboratory session to discuss all of the measurement techniques as well as the underlying theory. Since the group leader will personally and individually discuss the work with the instructor, it takes an extremely slip-shod individual to fail to make previous preparation for the interview.

The interview covers (1) a detailed discussion of measuring techniques, with actual circuits and connections drawn out on paper by the student *before* the interview. (2) The reason *why* the various readings are to be made. (3) What is to be done with the collected data.

The student must make advance preparation if he is to answer the various questions which the instructor may ask. If the leader does lack preparation, he

may be asked to make another appointment.

The results gained by instituting this system have been very gratifying. *First:* The group is ready to cooperate with the leader since they know that he has discussed the experiment with the instructor and that he actually knows what to do. *Second:* At least one student in the group knows what the aims of the experiment are and is able to see the forest without being confused by the trees. Of course the instructor points these things out in his pre-laboratory lecture but any teacher is ready to admit that the point is sometimes missed by the students. *Third:* Because of the organization, each man realizes that the experiment can be completed properly and on time. Thus the entire group works with a will and turns out much better work in less time.

While it would be admitted that this method *could* work, there are many factors which might cause it to fail. First: If the group knows that one man is responsible, are they not likely to lie down on the job? No. As a rule engineering students are interested in laboratory work and they want to do well unless they are discouraged by their own confusion (this desire is, however, not usually strong enough for them to reduce their confusion by adequate preparation). The occasional malingerer seems to be held in line by the fact that he will want cooperation when he becomes group leader.

Second: Isn't this going in the wrong direction, by only requiring *one* man to do any preparation? No, since the rule is that none of the men make much preparation. Furthermore the instructor still gives a pre-laboratory lecture to cover the theory. The lecture may be shortened since it need not concern itself with the practical details already discussed with the group leader.

Third: Can the slower men meet the challenge? Yes. In fact this one point makes the whole thing worth while. The first year that the conference method was tried by the author, it was introduced in the second semester. It was a real satisfaction to see those men who had gradually drifted into merely data taking during the first semester step in and take charge. This seems to be the best way of insuring that all of the men in the group progress together without hamepring the better men.

Fourth: Do the students like it and will they cooperate? Yes. Here are a few comments: "Good to have someone in the group who knows what has to be done," "Good experience," "We know that if we work, we can get out early" (a *very* powerful incentive).

Of course the conferences take up quite a bit of the instructor's time but the results are worth it. There is always the temptation to steer the laboratory experiments—perhaps because it salves the instructor's consicence—but experience has shown that this method will allow the material to be covered with the student still able to exercise his independence and ingenuity.

In the News

The **Engineering Societies Library** has prepared a Bibliography on Unionization of Professional Engineers to answer inquiries received by the Library from engineers, engineering students and others interested in the subject. The 100 references in the Bibliography are to pamphlets, and articles in magazines from 1937 to 1954 which are in the Engineering Societies Library.

ESL Bibliography No. 10: BIBLIOGRAPHY ON UNIONIZATION OF PROFESSIONAL ENGINEERS. 100 references. 8 p. Mimeographed. 1954. $2.00. Available from the Engineering Societies Library, 29 West 39th Street, New York 18, N. Y.

UPADI—What It Is, What It Does

UPADI—What it is: In Spanish it is the Union Pan Americana de Associaciones de Ingenieros. In English it is Pan American Federation of Engineering Societies. Initiated in Rio in 1949, about 18 nations have engineering organizations that are Members of UPADI and two other nations have organizations that are affiliated. Engineers Joint Council holds the membership for the United States. The headquarters is at present in Montevideo.

UPADI is an engineering organization which preserves the independence of member societies in their own activities and at the same time provides a new means for increased cooperation among engineers and industry of the Western Hemisphere. The objectives of promoting unity among engineers and progress in science and technology are obtained by encouraging, guiding and standardizing the efforts of engineers in the Americas; by holding periodic Pan American Engineering Congresses, Conventions and Exhibits; by encouraging travel of engineers among the American nations and the exchange of teachers, lecturers and students among the universities and schools and engineering associations; by developing rules of professional practice and codes of professional ethics; by contributing to closer technical relations among the American countries and by advancing the economic development of all American nations.

What it does: In addition to the initial meeting in Rio in 1949, UPADI has held three conventions at which subjects of interest on engineering education, standards, code of ethics, engineering phases of industrial and economic development, and others have been discussed. A copy of the Professional Code of Ethics may be obtained from Engineers Joint Council. (Unofficially and from the viewpoint of the United States, one of the objectives in connection with hemispheric solidarity is to keep the American nations looking to each other—rather than to Europe—for standards, specifications and engineering guidance in general. Also to increase the circulation of engineering periodicals in the American nations.)

Convention: The next Convention of UPADI will be held in Mexico City during 1956. James M. Todd, a past President of ASME, is President of UPADI Fund, Inc., and Vice-President of UPADI.

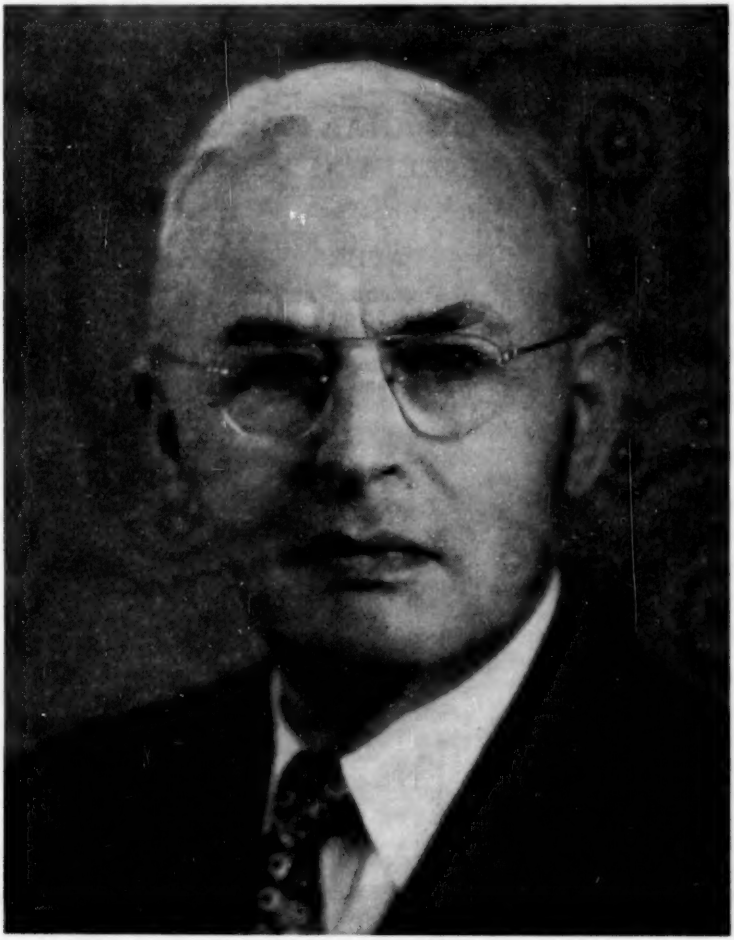
The American Rocket Society has joined **Northwestern University** in establishing a series of symposia in **Gas Dynamics.** The first symposium will be held on August 22–24, 1955 and its theme will be Aerothermochemistry. Papers to be presented will deal with 1) laminar flames; 2) turbulent combustion; 3) combustion instability; 4) ignition and the mechanics of sprays. Paper abstracts of about 300 words will be accepted until April 15, 1955 and the complete papers should be submitted by June 15, 1955.

Paper abstracts and correspondence concerning the Symposium should be sent to:

Gas Dynamics Symposium
Department of Mechanical Engineering
Northwestern University
Evanston, Illinois

The James H. McGraw Award in Technical Institute Education

To ARTHUR C. HARPER, *scholar, author, teacher, and administrator, for his outstanding contributions to technical institute education; for the stimulus he gave to young men who were his students during his distinguished career as educator; for his original developmental work in the organization and administration of technical institute curriculums at Pratt Institute and at the Wyomissing Poly-*



ARTHUR C. HARPER

technic Institute; for his creative writing as coauthor of the textbooks Kinematics and Kinetics of Machinery *and* Strength of Materials; *for his work in founding the American Apprenticeship Round Table and in the development of that organization's educational program; for his willing and energetic participation in the activities of professional societies in the field of technical education, this fifth annual James H. McGraw Award in Technical Institute Education is presented.*

The James H. McGraw Award in Technical Institute Education is an annual award of $500 for outstanding contributions to this field of education. The award is administered by the Technical Institute Division of the American Society for Engineering Education and is sponsored by the McGraw-Hill Book Company, Inc.

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The Teaching of Engineering Ethics*

By M. D. COOPER

Director, Mining Engineering Education, National Coal Association, Pittsburgh, Pa.

In order to obtain first-hand information in regard to teaching engineering ethics, the catalogues of 12 colleges and universities were examined. These were chosen because of the fact that those institutions have been visited by the Vocational Training and Education Committee of the National Coal Association. The Committee made the visits for the purpose of hearing informal reports by members of the faculties on their respective courses. Because these meetings have been pleasant and informative, the members of the Committee find themselves in a position to act as liaison officers between the mining industry and the educational institutions; and, for that reason, expect to continue the visits at the rate of two or three a year. It must be pointed out that the curricula were those in mining engineering as they were of primary interest to the members of the Committee; but, generally, freshman year was common to all branches of instruction in engineering and, in some cases, the same practice was followed through the sophomore year.

Mining is closely related to chemical, civil, electrical, mechanical, and metallurgical engineering. Therefore, it seems reasonable to choose it to represent the others. Among the 12 colleges and universities, there were 3 offering curricula in 5 years; and 9 in 4 years.

"Ethics" as a separate course was not listed in any of the catalogues, although "Religion" was noted in one where it was offered throughout Sophomore Year as a 3-hour recitation and lecture course. In the first term as "Religion 1," it is entitled, "The Life and Teachings of Jesus Christ"; and, is a survey course of the life and teachings as presented in the four gospels with application of the teachings to modern life. In the second term, "Religion 2" is called "The Beginnings of Christianity"; and is a study of the origin, founding, and early expansion of the Christian Church as recorded in the Books of Acts and the New Testament writings. Emphasis is put upon the basic doctrines of Christianity.

The Meaning and Value of Ethics

"Ethics" may be considered as a study of morals. Sometimes it is referred to as the science of moral duty, or of ideal human character. Since it is a science, it seems to have a clear relationship to engineering.

Engineering deals with materials, power, and human beings for the benefit of all mankind. Materials in the form of equipment and fuels; power, as electricity, steam, compressed air, gasoline or diesel engines; and human beings who design, operate, and maintain the means of providing necessities to progress are essential elements of engineering.

Accuracy is one of the virtues of engineering. It is taken for granted. Not so easily recognized in the development of engineering is beauty, yet the trend is all in that direction in the design of structures and machinery, and even their surroundings. Because many early engineering installations were temporary, not much attention was paid to appearances. As more permanent works developed, beauty was given greater consideration.

* Presented at the Mineral Engineering Division, ASEE, meeting, University of Illinois, June 15, 1954.

Human relations, another part of good engineering—often neglected in the past, are increasingly important. The relations of employer and employee; industry and community; competition; air and stream pollution; transportation; and many other factors of modern living are closely involved with the science of ethics.

Teaching Ethics

Since it is apparent that there is a good deal of ethics associated with engineering, the question arises: Shall it be taught as a separate course? Immediately, the usual cry goes up that engineering curricula are already overloaded. Is that true? An examination of the catalogues previously mentioned reveals that 10 out of 12 provide for technical or non-technical electives. Many have courses in business organization, introduction to mining, freshman engineering lectures, mine administration, seminars, professional problems, and technical society meetings during which at least some of the major elements of "Ethics" could be presented. A single lecture period devoted to a discussion of the "Faith of the Engineer" would be time well spent. A small part is worth much if it can be impressed on the minds and in the hearts of engineering students: "To my fellows, I pledge, in the same full measure I ask of them, integrity and fair dealing, tolerance and respect, and devotion to the standards and dignity of our profession."

Even in the technical courses, there are certain parts where the ethical considerations need special emphasis. Mining is a field in which this applies, perhaps less now than formerly. T. A. Rickard in his book, "A History of American Mining," commenting on the Comstock Lode, says: "On the whole, looking back at the record of the Comstock, we may conclude fairly that notwithstanding the mechanical skill of the constructing engineers at Virginia City, the Lode did more harm than good to mining, because it accentuated the gambling phase and subordinated the industrial function in its feverish operation."

It appears then that there is opportunity for a brief course in ethics, either as an elective or as a part of a professional or introductory course.

Value of Ethics to the Professional Engineer

The reputation of the engineer is founded on ethics as he is judged not only by his technical knowledge but just as much by his moral ideals. Herbert Hoover in his "Principles of Mining" writes: "Engineering sense is that fine blend of honesty, ingenuity, and intuition which is a mental endowment apart from knowledge and experience. Its possession is the test of the real engineer. It distinguishes engineering as a profession from engineering as a trade. It is this sense that elevates the possessor to the profession which is, of all others, the most difficult and the most comprehensive."

Engineers as citizens in the community are in a position to add to the welfare of their fellows by participation in worthy causes. In fact, they are so well prepared for such activities that there is a responsibility resting upon them.

Throughout the nation, the engineers are entrusted with great projects, many of them covering wide areas in two or more states. The ethics of their profession are especially prominent in such works.

George Herbert Palmer in his book, "The Field of Ethics," concludes that "Ethics is certainly the study of how life may be full and rich, and not, as is often imagined, how it may be restrained and meagre."

Conclusion

There is evident need of instruction in ethics for engineers. In spite of full curricula, time is available in electives or in connection with technical or non-technical courses, or in seminars for at least an outline of the subject. By precept or example, students of engineering may be made to understand that their fellow men respect good behavior.

Methods Used in the Presentation of Manufacturing Process Courses *

By M. L. BEGEMAN AND B. H. AMSTEAD [1]

In the engineering profession changes are constantly taking place, since industry, spurred on by necessity and aided by intensive research, is ever developing innumerable machines, processes, and materials. It is essential that engineers in training, particularly those who will work in industry, have a knowledge of the possibilities and limitations of these new developments. Also the economic aspects of both the processes and materials must be known if good design and low factory costs are to be obtained. Knowledge of how things should be done, what constitutes good workmanship, and the ability to apply engineering principles are important assets to the engineer.

Because of this rapid development and change, it is important that courses and curricula continue to be reviewed. Engineering education is not static and the training of engineers should reflect the progress and the trend in all new developments. However, in this discussion, we shall be limited to only one course in the curriculum, manufacturing processes, a course which should give the engineering student a comprehensive picture of present day manufacturing and the various techniques which have been developed. While the course title includes all manufacturing, actually the courses normally cover only the manufacturing of metal products and other commonly used materials. These courses usually include instruction in metal casting, forging, heat treatment of metals, hot and cold working, welding, machining, measuring tools, and frequently additional processes such as the forming of plastics, powder metallurgy, and wood processing.

Course Objectives

In the training of engineers in the technical fundamentals of these important processes and tools, much is also learned about materials and engineering fundamentals. Our problem then is to devise the best method possible to present this material to the student. This includes such decisions as to methods of presentation, material that should be included, and what emphasis each process should be given. With this in mind, let us consider the objectives of such a course and then determine how these objectives can best be attained. They have been stated many ways, and it is obvious that all such courses do not aim for the same goal. Some of the objectives frequently given are as follows:

1. To train engineers in the technical fundamentals of important manufacturing processes, engineering materials, and in the modern machine tools necessary for processing these materials. Such an objective stresses knowledge of metal cutting principles and applications involved in the operation of machine tools. It emphasizes a need for knowledge of manufacturing methods so that a designer may function for economical manufacture or

* Presented at ASEE Mechanical Engineering Sumer School, Navy Pier, Chicago, June 21, 1954.

[1] M. L. Begeman is Professor of Mechanical Engineering and B. H. Amstead is Assistant Professor of Mechanical Engineering at The University of Texas, Austin, Texas.

a production engineer may be able to make proper equipment selections for a given job.

2. To give engineering students some practical applications of engineering principles; that is, a knowledge which emphasizes the need for integrating practice with theory. Technical information, with the knowledge as to how it is to be applied, is most valuable.

3. To train students to appreciate workers who must operate the many machines of industry. Experience is an excellent teacher as it brings about appreciation and lasting memory of the work accomplished. It develops in individuals a viewpoint which must be practiced by those who lead and supervise others.

4. To develop a sense of creativeness in the individual. It is not important that certain manual skills for making things be developed, but knowledge of how things are made is an incentive to work out problems and to be creative.

In looking over the various courses offered in engineering schools, it is obvious that ideas vary as to how these objectives should be accomplished. There is a variation in empahsis which is reflected in the type of course given, subject matter covered, and the method of presentation which is selected. Examples of this variation are indicated in courses which emphasize:

1. Machine tools, their use, operation, and limitations. This type of course emphasizes the machine or process and for what it can be used.

2. Theory of metal cutting, metal forming, machinability, cutting tool forces, etc. Such studies border on research and attempt to bring out how cutting and forming operations can best be done.

3. Processes and machines, but with little or no emphasis on operation. Such a trend may be followed if there is a lack of time or appropriate equipment.

4. Study of processes and machines as they affect the design of products.

5. Engineering materials, their properties, and how they may be changed in form.

6. Operation of machines and processes. This should not be emphasized to the extent that the training becomes vocational in nature.

It is not implied that a course follow only one of the trends listed. It is quite possible to include several or all of them in a course, even though one factor is emphasized more than the others. Emphasis should be placed upon that phase of the work which develops the desired objective.

Types of Courses

Courses offered in manufacturing processes can be classified either according to the material covered or according to the method of presentation. If we consider the first classification, we find there are two methods used. First, there are schools offering single courses which cover all phases of the subject. There has been some trend for this type of course because of the limited time available in an engineering curricula. In order to include new developments in engineering and at the same time more cultural training, many schools now offer all their shop work in one course. This is probably the best procedure to follow for such situations. Close coordination of all phases of the work is possible in such a plan.

Secondly, the work may be offered in several separate courses, each one covering but one phase of the work, as for example, metal castings. This is probably the way most manufacturing process courses started years ago. The outstanding advantage is that by allowing time for a number of separate courses, more material can be covered than under the one-course plan. Coordination of separate courses is sometimes difficult and there is tendency toward over-emphasis of certain phases of the work. However, by having more emphasis on manufacturing process courses, the student has a more comprehensive training and is bet-

ter prepared for work in industry. A modification of this second arrangement exists when two courses are offered, each one including several phases of the work. This is an expansion of the single-course arrangement and is desirable if sufficient time is available.

If courses are classified as to the method of presentation, there are several possibilities. In reviewing the methods followed at various institutions, there appears to be wide divergence of opinion as to how this work should be taught. Each method should be evaluated in terms of the course objective. According to method of presentation, the following course plans are in use:

1. Lecture course with no laboratory work. Courses are presented in this fashion where there is no equipment available, in cooperative courses where practical experience is gained in various shops, and in cases where it is felt that most students have already had laboratory training in technical high schools or industries. In the conduct of these courses there is probably the feeling that the student is adequately trained in the knowledge of machines and processes by lecture and classroom work rather than by laboratory work. It is necessary to make considerable use of visual aids, since the student has no access to actual equipment. All of the objectives cited earlier in this discussion cannot be attained by this method of presentation, which no doubt accounts for the fact that it is not widely used. It was the experience of the authors in using this plan for training Navy students during the war that it was not satisfactory to either the students or instructor.

2. Lecture course with inspection trip period each week. An improvement of the lecture course plan is made when opportunity is provided for the students to visit plants and see equipment in action. An example of such an arrangement is a course having two lectures a week and one three-hour inspection trip period. The inspection trip is coordinated with the subject matter being studied in the text and students are usually asked to prepare a report of the trip. This plan of study requires close proximity to a highly industrialized area having many types of industries.

3. All laboratory work with occasional time out for lecture and demonstration. The first two methods described stress lecture and classroom work while this method places the emphasis on work in the laboratory. While there is no classroom lecture or discussion period provided, there must be occasional portions of the laboratory period set aside for demonstrations, lectures, or the use of visual aids. This method of presentation is used to get more contact hours with the students and can result in requiring more of the students for their credit than by other methods. Usually when this type of a course is given, outside assignments are not made and the value of text study is lost. There is also some tendency in these courses to stress operations rather than advantages and limitations of the process and the principles involved.

4. Combination of lecture and laboratory work. This is a compromise between the types of presentation mentioned above and is an attempt to combine their advantages. Such courses have provision for lecture, text assignments, actual laboratory experiments or machine operation and demonstrations, all of which includes most of the teaching methods that are used. Most courses are patterned along this line, although there is much difference in the way schools use their laboratory time. This matter will be discussed in more detail under the type of projects used.

Laboratory as a Means of Instruction

In looking over the methods of presentation and evaluating them, we must certainly consider the advantages and limitations of laboratory as a means of instruction. It appears that there is hesitancy on the part of some schools in

accepting this means of instruction as suitable for a course in manufacturing processes. Some of the advantages are:

1. A greater interest in the course is developed when the student is able to see and operate various machines.

2. The student is brought into a shop atmosphere. Here he learns something of the viewpoint of an individual who operates machines day after day. This cannot be obtained from textbooks or lectures.

3. A better knowledge of the process is gained. Certainly there is more opportunity for the student to learn when facts and theory are supplemented by laboratory work. With this increased knowledge there is a better appreciation of industrial operations.

4. The student is given an experience which may assist him in determining his lifework—at least the more industrial experience he has, the earlier he can make such a decision.

5. The ability of a student to work more independently on research and creative problems is improved by reason of his knowledge of "how to make things."

Disadvantages which can be cited for laboratory type instruction include:

1. Laboratory instruction is time consuming for both students and instructors.

2. Laboratory equipment is expensive. This tends to limit class size and causes teaching costs to rise.

3. Laboratory work is thought by some to be vocational in nature. Whether or not this is true depends on how the course is conducted.

In summary, it appears that there is much to be gained by using laboratory techniques in conducting a course of this type. This fact is verified by the success of cooperative training programs where a student alternates between school and industry giving each about an equal amount of time. These programs indicate that their success is due largely to the shop and laboratory type experience given them during their time with industry.

Types of Projects Used

As previously stated, the success of any laboratory instruction depends upon the type of work which is assigned the students. Here again we see wide variation in this phase of the instruction—projects vary greatly as do their aims. A survey of a number of engineering colleges indicates the following type of projects in use:

1. Small projects, each attempting to illustrate the use of some machine or operation. Projects of this type can usually be completed in one period or less and include such things as making a screw, mandrel, gear, test specimens, parallel bar, C-clamp, etc. Projects should be selected which give the student operating experience on a wide variety of machines. Emphasis should be more on the quantity of projects completed rather than excellence or quality achieved. This project method used for many years still enjoys wide use. Its principal disadvantage is that the work may become somewhat vocational in nature if the instructor is not alert. Also it does not bring out the principle of interchangeable manufacture.

2. Special projects of a more complicated nature which are not repeated, such as the building of a small press, a dynamometer, a polishing stand or grinder, or special equipment needed for research. While there may be good interest developed in a project of this sort, it does have the disadvantage that the work to be done is not balanced. That is, the student may be forced to work most of his brief time on the same type of equipment. Again there is a tendency for skill to be emphasized rather than the knowledge of the equipment used and engineering principles involved.

3. Report type projects involving experiments on tool life, cutting tool forces, cutting speeds and feeds, or special ma-

chining operations. On projects of this sort nothing useful is produced as the machine is operated only to obtain certain data. Upon completion of the experiment computations must be made, possibly curves prepared, and the results or conclusions of the work set forth. This type of project is used more in upper level courses than at the freshman or sophomore levels. It is a method which gives the student some idea of a research approach and yet teaches him something of the capabilities of the machine. Report type projects require more planning and preliminary instruction and involve the grading of a report.

4. Production-type projects where all parts are made on a quantity production basis. The idea here is to simulate actual production methods as used in industry. Projects of this type which have come to the author's attention include a drill press, grinding stand, milling machine vise, table saw, sheet metal tools, and other similar projects. Here again it is necessary to do a great deal of planning ahead and preliminary work such as the preparation of prints, operation sheets, parts lists, and class schedules. In addition there are jigs, fixtures, and special tools to be designed and made. Much of this preliminary work can and should be done in the design and advanced tool engineering classes under the supervision of an instructor. Each machine should be properly tooled up for some required operations with appropriate class schedules and instructions worked out.

If the preliminary work is complete and well done, a student is able to do much more work and operate more machines than by any other project method. In addition to becoming familiar with the machines, the student also learns something of production methods and tooling as used in industry. If the project selected does not use all the equipment desired, other projects can be added. The value of interchangeability of parts is brought to the student's attention in the assembly operations.

Case Study of Instruction Using a Single Course

At The University of Texas a single semester course, meeting one lecture hour per week and two three-hour laboratory periods per week, is used to present manufacturing processes material to the mechanical engineering students. This is a three-credit hour course.

A textbook is used and the subjects covered are pattern work, metal casting, forging, hot and cold working, welding, measuring tools, metal machining, plastics, and powder metallurgy. The seventeen weeks of laboratory are divided into four fundamental instructional units. Approximately two weeks (12 clock hours) are devoted to pattern shop instruction, approximately three weeks (18 clock hours) to instruction in metal castings, approximately three weeks (18 clock hours) to welding instruction, and the remaining nine weeks (54 hours) to instruction in the machining of metals. In both the lecture and laboratory visual aids are used liberally.

All of the work in the laboratory this past year has been centered around a single project. The project is an eight-inch circular table saw which is equipped with tilting table and adjustable saw height features. Although the project has been used only two semesters and continuing revisions are necessary, approximately 100 table saws have been finished each semester.

In the short time devoted to pattern shop work, emphasis is placed on the making of match plate patterns. In the foundry the fundamentals of hand and machine molding, core making, and metal melting are practiced by the student. Emphasis is also placed on quantity production of aluminum castings, since in each table saw there are nine separate aluminum castings weighing approximately twenty pounds. For 100 saws approximately 2500 pounds of aluminum must be poured in the foundry each semester if allowance is made for gates, risers, and scrap. Aluminum is

melted by means of a coke furnace, a gas-fired furnace, and an induction furnace. Brass and cast iron are melted and poured at least once each semester to acquaint the student with the processes involved.

In the welding shop the students learn the fundamentals of gas and electric welding. Again no appreciable skill is obtained by the student; however, enough ability is usually absorbed by the student for him to be capable of doing the very simple welding necessary on the saw frame. One three-hour period of the welding laboratory is devoted to demonstrations of electric resistance welding, flash welding, brazing, torch cutting, silver soldering, aluminum welding, inert gas-shielded welding, and other specialized processes in the field.

The first period of machine shop instruction is devoted to the demonstration of basic machine tools such as the lathe, shaper, planer, and milling machine. Thereafter when a student arrives in the laboratory he goes to a group of drawers and selects one drawer which contains all the special tools and instructions for a given operation and directs the student to a specific work place. The student punches "in" on a time clock and indicates on the time card the part number and operation number of the job he is on. Most of the machines in the laboratory are set up for production runs on parts for the saw. Both written and instructional help is used to "break in" a student on a machine or process new to him.

A student does not necessarily change jobs each day, but may change once or twice during the period. The instructors mingle through the class and each time a student appears to have had sufficient time on a machine to be familiar with the processes and the fundamentals involved, he is moved to another job. In order to check on the diversification of experience of the student in the laboratory, an instructor need only refer to the student's time card.

In all there are approximately fifty different parts made in the laboratory for this saw. The only parts which are purchased for the saw are the ball bearings, the saw blade, and the miter head. It is hoped that within a very short time the miter head can either be die cast or cast in a shell mold in the foundry laboratory.

During the last week of each semester the students work on the saw assembly line. This training makes them aware of industry's problems in mass production. It gives them the realization of the accuracy and quality of workmanship necessary for interchangeable manufacture. It is quite apparent that the esprit de corp of the student is increased when he is working on a project of this type. The student can, if he desires, purchase a saw for the cost of the materials alone.

There is considerable cooperation between various courses as a result of this project. The machine design classes furnish the drawings which are constantly being revised. The required and elective courses in industrial management, plant layout, time study, quality control, advanced metal castings, etc., now have a practical problem to which students can devote their energies. The advantages of an arrangement of this kind are obvious since any theories that an instructor or student may wish to advance in any of these industrial type courses can be tried out in the laboratory and their value determined. This method of presenting laboratory instruction appears to incorporate all the salient features of laboratory instruction.

Present Practice in the Teaching of Manufacturing Processes

Possibly some trends in the teaching of manufacturing process courses can best be studied by examining the practices of thirty-five engineering colleges selected at random. The following information was obtained from correspondence and in some cases the data was incomplete. The table is based on curricula in Mechanical Engineering, although it

was noted that the practice in Industrial Engineering curricula was quite similar.

Teaching Practice	Number of Schools
Method of Presentation	
No course given	1
Lecture instruction only	4
Laboratory instruction only (informal lecturers)	6
Lecture and laboratory	22
Lecture and demonstration	2
Type of Laboratory Work	
Small projects	18
Special (research type) projects	1
Reports (including inspection trips)	3
Production-type projects	8
No laboratory	4
Material Covered in	
Single semester course	9
Two semester course	15
Multiple courses (welding, casting, etc.)	10
Courses Taught by	
Industrial Engineering Department	6
Mechanical Engineering Department	22
Other	6
Classification of Student	
Freshman	1
Sophomore	20
Junior	4
Senior	1
Covered over several years	8
Credit Given	
Two hours	4
Three hours	7
Four hours	12
Five hours	4
Six hours	7

In studying the various course offerings of these schools, it should be noted that many of them have additional courses in the fundamentals of manufacturing processes other than those listed above. Such courses are provided for production options and electives for those interested in production work. The thirty-five selected schools in this survey constitute a representative and sufficiently large group to provide the following fairly accurate conclusions as to present practice and trends in the teaching of manufacturing process courses:

1. Practically all engineering schools give a basic course in this subject. The few that do not recognize a need for a knowledge of the subject, but differ as to how and when it should be obtained.

2. A combination of lecture and laboratory work is the usual method of presentation. In cases where laboratory work alone is scheduled, it should be noted that informal lectures and demonstrations are generally used to supplement the work.

3. In recent years there has been some trend towards a single course covering all phases of the subject; however, many schools are still spreading the work over two semesters. In the latter case foundry, pattern work, forging, hot and cold working, welding, and possibly other subjects are given in one semester, while the second semester deals principally with machine shop work and inspection. Multiple courses; that is, a series of courses, each on a single phase of shop work, require more time than most schools wish to allow and are considered difficult to coordinate.

4. Most courses are taught in the Mechanical Engineering Department.

5. Courses in manufacturing processes are predominantly scheduled in the sophomore year. This appears to be a desirable place in the curricula for the course to best help the student in his design work.

6. Most Mechanical Engineering curricula provide approximately four semester hours for this work.

7. There is a general feeling that this course should have close coordination with other required courses. Probably its greatest value is that it teaches the student how to design parts that can be made economically. Design work requires more than just stress calculations—materials must be selected, heat treatments specified so that desired properties are obtained, tolerances selected in line with

both functional requirements and the ability of the machine to produce them, and often the selection of the process itself.

The above survey emphasizes the fact that several methods of teaching a fundamental course in manufacturing processes are still being used. Although on each point tabulated there is one procedure followed by the majority of the schools, it cannot be concluded that that procedure is the best one. To make this decision we must continually review our objectives and see whether or not they are being accomplished. Are we training the student in the technical fundamentals of important manufacturing processes? Is the student learning and observing practical applications of engineering principles? Is he developing a sense of creativeness and gaining some appreciation of work accomplished?

These questions are all difficult to answer in a positive manner. The student's response to the course, his interest, and how he applies the information to his later courses all give some indication as to the answer. Likewise the instructor must sense whether or not he is doing the job he should and if he is getting the desired results. Certainly departments should periodically review their courses to see whether or not they reflect the progress which is constantly being made in the engineering field.

College Notes

The **University of Florida, North Carolina State College, Virginia Polytechnic Institute** and the **Southern Regional Education Board** are jointly sponsoring a series of cooperative summer sessions in statistics. The first of these cooperative graduate summer sessions was held during the summer of 1954 at Virginia Polytechnic Institute. At this session there were 89 students from 26 states and the District of Columbia, and from India, Finland, Canada, Australia, China, Hawaii and the Philippines. The following courses were offered: Engineering Statistics, Statistical Methods I, Statistical Theory I (Probability and Inference), Biostatistics, Quantitative Genetics, Rank Order Statistics, Multivariate Analysis, and Seminar on Recent Advances in Statistics. Classes ranged in size from 9 to 34, with an average of 20. The second session will be held at the University of Florida from June 20 to July 29, 1955. A session is scheduled to be held at North Carolina State College in 1956, and another at Virginia Polytechnic Institute in 1957.

In the News

Appointment of James M. Mitchell as Assistant to the Director of the **National Science Foundation** has been announced by Dr. Alan T. Waterman, Director. Mr. Mitchell's responsibilities will be largely concerned with the Foundation's program of fact-finding studies on scientific activities and manpower in government, industry, and universities.

A fund of $291,000 for grants to univertities and colleges to help improve the teaching of science and mathematics was announced by the **Du Pont Company** as part of its $800,000 aid-to-education program for 1955–56.

THE T-SQUARE PAGE

CONTRIBUTIONS TO ENGINEERING EDUCATION

BY THE

DIVISION OF ENGINEERING DRAWING

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University of Nebraska

HAROLD P. SKAMSER, *Secretary-Treasurer*
Michigan State College

WILLIAM E. STREET, *Vice Chairman*
A & M College of Texas

IRWIN WLADAVER, *Editor of*
the T-Square Page
New York University

Graphics and Differential Equations

By PROFESSOR STEVEN A. COONS

Assistant Professor of Graphics, Massachusetts Institute of Technology

The solution of ordinary differential equations by machine depends upon two very simple ideas; the use of integrators, and the use of feedback. Thus the mechanical hook-up for solution of the differential equation for a series circuit in electricity may be diagrammed:

$$L\frac{di}{dt} + Ri + \frac{1}{C}\int i\,dt = e$$

or

$$\frac{di}{dt} = \frac{1}{L}\left(e - Ri - \frac{1}{C}\int i\,dt\right)$$

Now the integrations involved may be performed graphically, and feedback simply means comparing the result with the original assumptions. Thus to solve a differential equation graphically we assume a graph for di/dt over a suitably small interval of time, Δt, and perform the indicated operations. The result is a graph of di/dt over the same interval which is different from the original assumption and is a closer approximation to the true function. If we repeat the circuit of the steps in the process, the successive graphs tend to consolidate, and eventually further excursions around the circuit fail to show any difference between the assumed di/dt and the di/dt

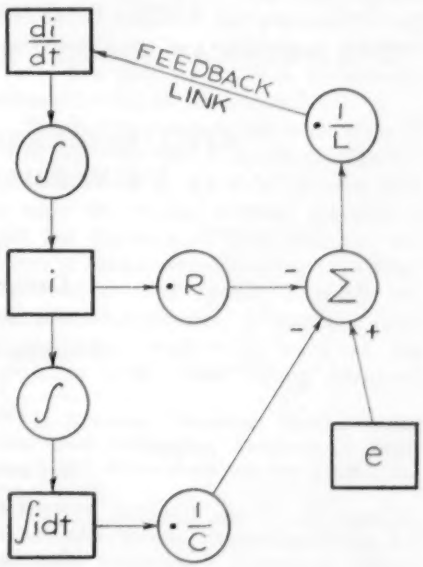

FIG. 1

fed back. Then over the interval we have a solution of the equation, and can proceed to the next Δt. It turns out that the successive trials converge rapidly, so that this is a practical method to use. But more than being merely a graphical device, it has value because it demonstrates in a tangible way the meaning of differential equations; one can actually see the solution generate itself, and one is more aware of the part played by the derivatives of various orders and their interaction.

In the present example, the voltage "e" may be any function of time that can be plotted; then the voltages in the various branches of the circuit appear as graphs which draw themselves almost automatically. Moreover, the diagramming of such an equation is precisely the step one would take in preparation for setting it up on a computer. Hence this graphical approach to differential equations is an educational tool which sheds light on their nature and their mechanical solution.

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A Graduate Curriculum in Technical Writing

By STERLING P. OLMSTED

Head, Department of English, Rensselaer Polytechnic Institute

That there is a rapidly growing need for technical writers and editors hardly requires demonstration. This article is a report on an attempt to meet that need, now in experimental operation at Rensselaer Polytechnic Institute.

Mr. Christian K. Arnold, writing in the JOURNAL for November 1954, proposes an undergraduate curriculum which includes "basic training in the tools of both the editor and the scientist: composition, physics, mathematics, and chemistry as a bare minimum." The R.P.I. program seeks to accomplish somewhat different results by superimposing a graduate major in technical writing and editing on an undergraduate education in science or engineering.

Other solutions will undoubtedly be devised as the demand becomes more insistent. The field is a large and varied one, and it is still growing. At least 2000 periodicals are devoted to various fields of interest in industry and business, and another 1500 are published by industry itself. Many companies have technical writing departments whose job may range from the editing of engineering reports to the preparation of proposals and the writing of operation and maintenance manuals. According to one estimate, there are over 10,000 technical writers in the country today, but the boundary lines of the profession are so nebulous as to make all estimates highly conjectural. Technical writers are not only numerous; they are becoming profesionally conscious. Within the past year societies of technical writers have been organized in the New York, Boston, and Schenectady areas, and the head of one large technical writing group has even proposed a new term, "publications engineer," to describe those working in the field.[1]

Up to this time most of those who man this growing enterprise have been either scientists or engineers who have developed an interest in writing (or who have been drafted for writing and editing) or else English or journalism graduates with an interest in science. Apparently the biggest demand is for engineering graduates who can write. H. C. McDaniel and C. A. Scarlott, writing in the *Journal of College Placement*, assert that it is "essential that a technical editor have a formal engineering education." They add that "of 32 technical and trade magazines polled on this question, all but two required an engineering degree. These two preferred a B.A. in business administration to journalism."[2]

The R.P.I. program has been planned with this requirement in mind. The degree offered is a *Master of Science with a major in technical writing.* Candidates for this degree must hold bachelors' degrees in science or engineering. No English majors need apply. Students are required, furthermore, to continue their scientific or engineering work at the graduate level, either taking advanced

[1] R. Hamlett, "Technical Writing Grows into New Profession: Publications Engineering," *Proceedings of the I.R.E.*, October 1952.

[2] H. C. McDaniel and C. A. Scarlott, "Technical Writing Opportunities for Engineering Graduates," *Journal of College Placement*, May 1954.

courses in their undergraduate field or branching out into another field for which they are qualified. The advantages to the technical writer of broadening his scientific background are obvious.

The greater part of the program, however, is in writing, editing, and related subjects. The required writing courses which form the core of the program have been designed to furnish the student with balanced experience in composition. A year's course in writing and editing is handled essentially as a technical writing laboratory. Here, emphasis is placed on developing facility. Students gather material, write, edit, re-write, adapt their own and other men's material to new purposes and new readers, expand and condense—always under continually increasing pressure of rigid deadlines and exacting requirements in copyfitting.

Running parallel with this course are two other one-semester writing courses in which there is less pressure to produce and more emphasis on finished, polished work. In the first of these courses students concentrate on the development of a good prose style. They begin by examining the theory of language and the problems of style and organization, attacking the subject with the same scholarly rigor demanded of the English major in a traditional graduate school. They then go on to apply the theories which they have studied, producing articles on a variety of subjects. In the second course, *Writing for Publication,* students take the next step: they not only try to write finished articles, they also slant them toward particular journals and submit them for possible publication. The object of this course is not to turn out free-lance writers, but to give students oportunity to develop individual styles, on topics (technical and non-technical) in which they are interested.

Other Courses

The other courses in the technical writing major are related to this core in various ways. *Mechanics of Publishing,* for example, is designed to make students better writers by giving them some knowledge of the actual techniques by which material is reproduced and of the editorial organizations which are responsible for this work. The objective is not to turn potential technical writers into printers or bookbinders, but to help them understand the possibilities and limitations of the finished product for which they are writing and planning copy. Similarly, a one-credit-hour course, *Law for Writers,* is aimed not at producing an expert in the laws of copyright and of libel, but rather a writer who will avoid producing copy that an editor or lawyer would reject. An elective course in *Methods of Presentation* emphasizes the non-verbal techniques which are used so extensively in technical publications.

As a counterbalance to these specialized, practical courses, and to guard against the tendency to "journalese" inherent in *Writing and Editing,* students are required to take a term course in *Scientific Masterpieces,* which is intended to give them not only some understanding of the development of English prose style but also an acquaintance with the historical backgrounds of science and technology. The student who wishes to go more deeply into the background and implications of science may elect a course in the *Philosophy of Science,* while the man who wants to know more about the range of his profession may elect *Scientific Writing in America.* This last course has also been planned in the best traditions of the graduate seminar in English in so far as these traditions are applicable to this field. The student is asked to carry out an independent investigation of the history and methods of a particular publication, type of writing, or mode of presentation. Since this is an almost untouched field for scholarly investigation, the possibilities of original work are immense.

So far R.P.I. has not required a Master's thesis as part of the program.

If it elects to do so in the future, it is probable that much of the spade work for such theses will be done in the course in *Scientific Writing in America.* At the moment it appears to those in charge of the program that the amount of research and writing assigned during the year makes a thesis requirement unnecessary.

It is perfectly clear that technical writers and editors can be developed through on-the-job training. After all, this is the way they have been developed in the past. Most professions were at one time in this position: they first trained practitioners by the apprentice system. As they came of age, however, they began to require academic instruction which would fit a man not just for work with one organization, or one particular kind of job, but would give him background, versatility, and a knowledge of the whole field. This the R.P.I. program in technical writing attempts to do. It has not, so far, been slanted exclusively either to the technical press or technical writing in industry. Experience may show that such slanting is useful. It may also show that for some kinds of technical writing jobs, an undergraduate program such as that suggested by Mr. Arnold is the ideal preparation. At the moment the R.P.I. program is based on the assumption that a full undergraduate engineering education, or an equivalent education in science, is a prerequisite to a career in technical writing.

College Notes

An 8-week summer program of advanced study in highway engineering, open to instructors in engineering colleges, will be held at the **University of California**, Berkeley, beginning June 20, 1955, with the cooperation of the Institute of Transportation and Traffic Engineering. Twenty grants-in-aid of $650 each are available to make practicable the enrollment of instructors from throughout the United States. This financial assistance has been made possible by a grant from the Automotive Safety Foundation.

Northeastern University will break ground next June for the construction of a $1,500,000 Classroom-Laboratory Building. Pres. Carl S. Ell has announced that the Corporation had sanctioned the four story, 40 classroom structure to be completed by June 1956 for use by students by the fall of 1956.

A new research grant of almost a quarter of a million dollars will enable the **University of Pittsburgh** to continue its long-time contributions to the efficiency of the U. S. Navy's aviation ordnance equipment. Dr. G. R. Fitterer, dean of the Schools of Engineering and Mines at Pitt, announced that the U. S. Navy Bureau of Aeronautics has granted the schools $225,000 for a period of two years to study aviation ordnance equipment.

A clearing house for the Nation's military research and development in the field of electronic parts has been established by the Department of Defense at the **University of Pennsylvania.** It is the Secretariat of the Defense Department's Advisory Group on Electronic Parts. It is staffed and operated by the University's Institute for Cooperative Research, under Government contract.

The establishment of a professorship in electrical engineering at **Columbia University** through a grant from the General Electric Company was announced by Dr. Grayson Kirk, president of the University. The professorship will be used for teaching and research in the fundamentals of generating, handling and processing energy.

Engineering Economy and Operations Research*

By L. G. MITTEN

Assistant Professor of Industrial Engineering, The Ohio State University

In considering the relationship between Engineering Economy and Operations Research, we can compare them on the basis of

1. Purpose,
2. Methodology, and
3. Techniques.

I will undertake a definition of purposes and an analysis of the general problem considered by both disciplines.

In very general terms, I think it could be agreed that Engineering Economy and Operations Research have a common purpose or function; to provide a basis for executive decisions. Since many techniques are concerned with decision making, some of the generalized facts of decision theory should provide an interesting framework within which to compare and contrast the two methods.

The first aspect of decision making which we shall consider is the decision situation, i.e., the kind of situation which calls for the making of a decision. The decision situation may be characterized by the following conditions:

1. There is a purpose or objective which is desired to achieve,
2. Some action is required in order to achieve the objective,
3. There is a set of alternative actions by which the objectives might possibly be achieved, and
4. There are, in some sense, conflicting elements among the courses of action which might be pursued.

An important difference between engineering economy and operations research is to be found in the type of decision situations falling within each of their provinces. Engineering economy, almost by definition, is concerned with those situations in which the objectives and the alternative courses of action entail both engineering and economic considerations. Thus, if from the set of all decision problems we select the two subsets of engineering problems and economic problems, the intersection of these two subsets represents the set of problems to which the engineering economy techniques are primarily applicable.

Operations research deals with a somewhat different group of decision problems, namely, the sub-set of decisions concerning operations. Now I am not at all sure that I understand precisely what is encompassed by or excluded from the field of "operations" (any more than I am sure that I understand the precise limitations on the field of engineering). However, some notion of the meaning of the concept may be obtained from the folowing definition; an operation is a system of interrelated machines and/or men and/or materials. Despite its inadequacies, the above definition does give us some crude basis for comparing the sets of decision problems treated by engineering economy and operations research.

It is clear that a large number, but not all, engineering economy problems may also be considered as operations research problems, and, in addition, operations research problems encompass a vast area not included within the domain of engi-

* A paper presented before the Engineering Economy Summer School of the American Society for Engineering Education, June 13, 1954, at the University of Illinois.

neering economy. Thus, while both techniques deal with decision problems and while the two fields overlap considerably, I feel that we must concede that the scope of problems considered by operations research is very much broader than in the case of engineering economy.

In addition to differences in the type of problem considered, operations research and engineering economy differ significantly in some aspects of problem solving procedures. For our purposes we may conceive of the "decision procedure" as consisting of

1. Model construction,
2. Criterion definition,
3. Choice, and
4. Action.

Model Construction

Most (if not all) of man's contacts with reality are accomplished through a series of symbolic transformations. This is true even on the most primitive level such as perception where the external stimulus is transformed by the receptor organ into an electrical impulse transmitted by the nervous system to its destination. The electrical impulse is, in a very real sense, a symbolic representation of the initial stimulus, i.e., it is a model which represents the initial stimulus. At the much more sophisticated level of decision making symbolic representation and model construction play a crucial role. The models used in various decision making methods may differ in a number of ways; they may range from a highly formalized symbolization (such as mathematics) to constructs so vague and tenuous that they are incapable of being formulated in even verbal terms. Models also differ considerably in the degree of isomorphism existing between a model and the situation being described. By way of clarification of the preceding statement we need merely point out that all model construction is an abstracitve process (i.e., from among the elements and relationships existing in the real situation only those which are considered to be relevant to the problem are abstracted from the situation, symbolized, and assigned a role in the model). If and assigned a role in the model) and if too few elements and relationships in the situation are selected for symbolization and inclusion in the model, or if the symbolization is inadequate for an accurate portrayal of the nature of the element or relationship, then the resulting model will not represent the situation with sufficient precision.

The models used by engineering economy and operations research are similar in that they are, in general, quite highly formalized and it is this fact which differentiates them from the cruder forms of decision making by hunch or guesswork. There are, however, some extremely important differences between the models used by these two disciplines. In the first place, the approach made by the engineering economist and the operations researcher to the process of model construction are quite different. Model construction is a conscious process for the operations researcher; the word model is an important part of his working vocabulary and he thinks in terms of the "diffusion model," "linear programming model," "queuing model," etc.. He *knows* that he is constructing models and he has received considerable training and great skill in this art. On the other hand, although the engineering economist uses models describing micro economic-engineering situations, he is not, in general, aware of the fact that he is using a model and is not likely to give too close attention to the formal steps in its construction. In fact, we might say that the engineering economist selects an "off the shelf model" rather than assembling his own. We might go even a step further and state that the activity of most practitioners of engineering economy merely determine the values of the set of parameters for one of three or four highly standardized models and that the process of model construction or even

model selection is generally outside his realm (at least with respect to economic models).

With the above facts in mind, it is readily understandable that the models employed by operations research workers are considerably more sophisticated and, I believe, more accurate than those of the engineering economist. No small part of the effectiveness of operations research workers in the field of model construction is due to the "team approach" which characterizes most of operations research work. Within the team will be found a wide variety of disciplines, each discipline encompassing, in general, many different analytic tools which form the raw material for model construction. Thus, in addition to the standard engineering techniques, operations research makes extensive use of probability theory, the theory of stochastic processes, programming theory, calculus of variations, etc. As a consequence, the operations research worker is able to construct adequate models of situations whose complexity would baffle the engineering economist. Until the engineering economist becomes a much more conscious model constructer, and until he masters a much wider variety of analytic techniques (including those from the fields of the social sciences as well as the physical sciences and mathematics), he will not be nearly so effective as the operations research worker in performing his basic function, namely, providing a basis for executive decisions.

Criterion Measures

Another important aspect of the decision procedure is the definition of the criterion of choice or the measure of value or of merit, as it is sometimes called. In the case of engineering economy, the measure of merit is almost always defined in terms of cost, profit, and/or percent return on investment; it is the fixed criterion in economy studies, unquestioned by almost all engineering economists. In operations research, however, the definition of an appropriate measure of merit usually poses a very large problem which is consciously considered, weighed, and discussed. As witness of the fact that very serious attention is given by the operations researcher to the problem of criterion measures, it is interesting to note that a considerable amount of space has been devoted in the last two issues of the *Journal of the Operations Research Society of America* to the problem of value theory.

Thus, we find that the attention given to the problem of criterion measures is one of the characteristics which differentiates operations research from engineering economy—the engineering economist taking the criterion measure as given and unquestioned, while the operations research worker gives careful attention to the definition of a criterion measure which will be appropriate for the problem under consideration. As a consequence of this fact we find that operations research is able to give adequate solutions to a whole set of problems which the techniques of engineering economy cannot handle. In addition, among those problems to which both techniques are applicable we very often find that the solution obtained by the operations research worker is superior to that of the engineering economist because of the greater attention given by the former to the problem of criterion measures and because of his greater flexibility in dealing with the problem of value in general.

Let us review briefly the conclusions drawn from the preceding analysis. First, we find that both engineering economy and operations research have the same general purpose—to provide a basis for executive decisions—but that the problem area encompassed by operations research is considerably broader than that of engineering economy, and, in fact, the former includes a great deal of the area covered by the latter. Second, it is seen that operations research workers are generally much more adept at the construction of models of the decision situation than are engineering economists, and that their

models tend to be more sophisticated, more adaptable, and to provide a better representation of the situation under consideration. Finally, we note that the operations research worker is much more acutely aware of the criterion problem than is the engineering economist, and that as a result he is able to tackle a wider variety of problems and come up with generally more adequate solutions.

There is another factor which we have not yet considered, however,—the relative economy of the two methods. Operations research is an expensive undertaking, some current estimates indicating that it costs approximately $20,000 per year in direct and indirect costs to support one operations research worker. For engineering economists, my guess would be that the cost is, on the average, considerably less. Thus, for the vast majority of more or less routine decision problems that arise in the course of industrial operations, it would appear that engineering economy is an adequate and economic tool; it is only in those problems of considerable complexity, or those where refined methods might be expected to yield large savings, or in those cases where engineering economy techniques are inapplicable that operations research can be economically justified.

Conclusion

In conclusion, I would like to state my personal opinion that operations research is the best thing that ever happened to engineering economy. There is no question but that new techniques are and will be developed in the field of operations research which can be learned and used by the engineering economist; in addition, it is imposible to estimate the tremendous value to engineering economy of the stimulating effects produced by the great creative effort going into a friendly competitor such as operations research.

College Notes

The University of Michigan, College of Engineering, has announced two Intensive Courses in Automatic Control. The first is scheduled for June 13 to 18 inclusive, and the second for June 20 to 22, 1955, inclusive. The courses are intended for engineers who find it necessary or who wish to obtain a basic understanding of the field, but who cannot spare more than a few days for this purpose. The aim of the courses is to make it easier to learn by a coherent presentation of the fundamentals of modern automatic control and by providing a comprehensive set of notes to serve as a framework for further study.

April 15 is the closing date for registration. Further information may be obtained by writing to Professor L. L. Rauch, room 1521, East Engineering Building, University of Michigan, Ann Arbor, Michigan.

Dr. Robert A. Ramey, Jr., manager of the Magnetic Development Section of the Materials Engineering Department of the Westinghouse Electric Corporation (Pittsburgh), has been appointed Visiting Webster Professor of Electrical Engineering at **MIT** for the second semester of the current academic year.

Minutes of Executive Board

A meeting of the Executive Board of ASEE was held at Northwestern University, Evanston, Illinois on Monday, December 13, 1954 at 10:15 A.M. Those present included: N. W. Dougherty, *President;* W. L. Everitt, B. R. Teare, Jr., H. K. Work, *Vice Presidents;* C. W. Farnham, *Treasurer;* A. B. Bronwell, *Secretary.*

Appointment of the New Secretary

The Executive Board reviewed correspondence regarding all of the proposed candidates for the new Secretary to succeed Professor Bronwell, who is resigning to accept the position as President of Worcester Polytechnic Institute. Dean W. L. Everitt absented himself during the discussion and voting on the new Secretary, since one of the candidates under consideration was from the University of Illinois. President Dougherty and Professor Bronwell reported on several visitations to college campuses to interview candidates and examine facilities. A number of the letters of recommendation specifically requested that the Society headquarters remain in the Middle West, since this is near the geographical center of ASEE membership.

After considerable deliberation the Board voted to invite Professor W. Leighton Collins of the University of Illinois to take the position of Secretary of ASEE. The University of Illinois has offered to provide adequate space for the Society headquarters. It was recommended that the new office at the University of Illinois be set up about February 1.

The Executive Board expressed the hope that Marion Strohm would continue as the Executive Office Secretary and voted her a salary increase. The Board also voted to pay her room, meals, and travel expenses in connection with setting up the new office. It was decided to continue Professor Watson as Editor of the JOURNAL OF ENGINEERING EDUCATION throughout the current school year. The Board believed that it would be desirable to locate the Editor and Secretary in the same office so that they can exchange viewpoints on Society operations and also interchange secretarial assistance. It was suggested, therefore, that the editorship of the JOURNAL be moved to the University of Illinois as soon after June 30 as is convenient with the new Secretary.

Professor Bronwell stated that he would be glad to work with Professor Collins in effecting a smooth transition and will be available for consultation on ASEE problems. The Commencement Exercises at Worcester Polytechnic Institute occur on Sunday preceding the Annual Meeting; hence he may be delayed in arriving at the Annual Meeting. He further stated that the Society headquarters office has been preparing a Procedures Manual for the past five years, listing all the recurring responsibilities in the ASEE office. This will be helpful to the new Secretary in looking ahead and planning the Society operations.

Announcement Regarding the New Secretary

The Executive Board requested that Professor Lisle Rose prepare a publicity statement for publication in the Yearbook issue of the JOURNAL OF ENGINEERING EDUCATION, together with a photograph of the new Secretary. It was also suggested that this announcement be sent to other technical journals.

Resolution of Appreciation to Northwestern University

The Executive Board voted unanimously to send Northwestern University a

resolution of appreciation for space and facilities provided for the Society and also for the use of the Secretary's time.

IAESTE

The Secretary reviewed the recommendation of Mr. Boring that ASEE participate in the IAESTE program. This provides for an exchange of foreign students during the summer months for work experience. The advisability of participating in the IAESTE program was discussed as compared with that of attempting to provide job experience for foreign students who are already in this country. The Board suggested that a meeting might be arranged between Mr. Boring and members of the ECAC International Relations Committee to discuss these various proposals.

Graduate Study Project

The Executive Board reviewed the proposal as submitted by the Ad Hoc Committee studying the Graduate Study Project. The Board recommended that the Committee continue its investigation and prepare a specific proposal of topics to be studied and methods of achieving the results. In regard to finances, the Board recommended that the Ad Hoc Committee consider the financial needs of the project as a whole, rather than merely the needs of the first year of operation, since it is felt that a single appeal to industry would be much more favorably received than multiple appeals.

Humanistic Social Research Project

The Executive Board voted approval of the contract extending Dr. Gullette's services as director of the Humanistic Social Project on a part-time basis for another six months from January 1 through July 1, 1955.

Suggestion for a New Executive Board Member

A suggestion of the Secretary that the General Council be invited to elect a professorial member of the Executive Board from among their ranks was discussed. The purpose of this suggestion is to provide for a professorial member of the Executive Board, without at the same time placing roadblocks in the way of engineering deans who might be elected to the Board through the normal channels of officer election. This plan could go into effect without Constitutional amendment, although if adopted, it might be desirable to regularize it in the future by a Constitutional amendment in order to give the additional member of the Board vice presidential status.

The proposal suggested that the new vice president be given a certain area of responsibility in connection with the operation of committees of the ASEE. At present, the vice president in charge of Divisions and Committees has 35 different Divisions and Committees to supervise. This is such a large group that the vice president seldom attempts to maintain personal contact with more than a few of the Divisions and Committees within his area of operation. Therefore, a sub-division of work here might be desirable. The cost to the Society would be the travel expense of the new Board member to meetings of the Executive Board, which would amount to about $800 per year. It is felt that this is a small expense as compared with the advantages of having a member of the Executive Board with professorial rank.

The Board voted to send this suggestion to members of the General Council for their review.

Report of the Financial Policy Committee

A report of the Financial Policy Committee, recommending that the ASEE make additional investments in savings accounts, even though the money might have to be drawn out during certain months of the year when the Society cash account reaches its low ebb, was discussed. It was decided to table this matter for further consideration of the Ex-

ecutive Board after the new secretarial office is set up.

EJC Constitutional Amendments

The Executive Board reviewed the proposed amendment to the EJC Constitution and recommended favorable consideration, but requested that they be sent to the General Council for official vote.

ASEE Summer School

The Executive Board voted approval of two summer schools, one to be sponsored by the English Division and the other to be sponsored by the Chemical Engineering Division.

NSPE Affiliation with ECPD

A request from ECPD that the Society vote on NSPE becoming a constituent member of ECPD was favorably voted.

Authorization of Purchase of Furniture

The Executive Board voted to appropriate $1500 of the special projects reserve for the purchase of additional office furniture so that the Society will have its own office furniture, rather than relying on the host institution.

Travel Expense of Professor Bronwell

The Executive Board voted to authorize travel expenses for Professor Bronwell on official ASEE business during the transition period in order that he can work effectively with Professor Collins in making a smooth transition to the Secretary's office.

Statement of Professor Bronwell

Professor Bronwell expressed his grateful appreciation for the excellent cooperation he has received from the officers and membership of ASEE during his term as Secretary. The Society operations have increased substantially in scope and significance and the Society has been able to enlist the active support of the engineering colleges in its projects. This has been highly instrumental in cultivating an open-minded and inquiring attitude and in affecting implementation of its ideas.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

Sections and Branches

The **National Capital Area Section** of the ASEE held its first meeting for the year 1954–1955 at McMahon Hall Auditorium of the Catholic University of America on October 5, 1954, with Chairman Michalowicz presiding. During the short business session, it was announced that the principal theme for this year would be University-Industry Relations, and that the Winter Meeting would be held at the University of Maryland on February 1, 1955.

Dr. Henry H. Armsby, section representative to the General Council, made a complete report of the Annual Meeting in June, 1955. Among many items may be mentioned: (1) the change in dues; (2) adoption of a canon of ethics; and (3) award of honorable mention to Professor Adams, winner of our section's YET paper contest.

The principal speaker was Dr. Thomas J. Killian who sketched the development of the cooperative college movement from its inception in 1916 to the present time with a total enrollment of approximately 13,200 students.

New Members

ANDERSEN, JOHN R., Irrigation Specialist in Civil Engineering, South Dakota State College, Brookings, South Dakota. E. E. Johnson, W. H. Gamble.

ARNOLD, FRANK R., Acting Assistant Professor of Mechanical Engineering, Stanford University, Stanford, Calif. B. M. Green, W. M. Kays.

BAGGARLY, STEWART, Assistant Professor of Mechanical Engineering, Louisiana Polytechnic Institute, Ruston, La. L. R. Daniel, Jr., J. G. Chumley.

BAKER, MARGARET R., Special Instructor in Engineering Drawing, University of Texas, Austin, Tex. J. Lenhart, N. C. McGuire.

BENEDICT, NORMAN V., Instructor in Industrial Technology, Calumet Center of Purdue University, Hammond, Ind. M. E. Gyte, P. T. Meier.

BERGSTRESER, NEIL E., Assistant Professor of Civil Engineering, South Dakota State College, Brookings, So. Dak. E. E. Johnson, L. L. Amidon.

BERRY, FRANCIS R., JR., Assistant Professor of Engineering Design, University of California, Berkeley, Calif. J. Frisch, C. F. Garland.

BILLINGSLEY, JOHN G. S., Associate Professor of Mechanical Engineering, Norwich University, Northfield, Vermont. C. A. Renfrew, W. D. Emerson.

BORST, LYLE B., Chairman of Physics Department, New York University, New York, N. Y. Y. Beers, T. Saville.

DAY, JAMES A., Assistant Professor of Engineering Drawing, Wayne University, Detroit, Mich. R. W. Grant, H. P. Nelson.

DERKS, RICHARD J., Assistant Professor of Mechanical Engineering, University of Notre Dame, Notre Dame, Ind. C. C. Stevason, C. R. Egry.

DOUGLAS, DONALD C., Assistant Professor of Engineering Drawing, University of Michigan, Ann Arbor, Mich. F. H. Smith, R. S. Heppinstall.

FAGE, JOHN H., Instructor in Engineering, Pittsburgh Technical Institute, Pittsburgh, Pa. R. C. Gorham, J. R. Jackson.

FATOUT, PAUL, Professor of English, Purdue University, Lafayette, Ind. H. B. Knoll, G. E. Lommel.

FIREY, JOSEPH C., Assistant Professor of Mechanical Engineering, University of Washington, Seattle, Wash. P. L. Balise, J. B. Morrison.

FISK, GARRY L., Assistant Professor of Civil Engineering, South Dakota State College, Brookings, So. Dak. E. E. Johnson, W. H. Gamble.

FRYBERGER, E. L., Assistant Professor of Electrical Engineering, Valparaiso University, Valparaiso, Ind. H. C. Hesse, C. E. Peller.

FRYXELL, BURTON L., Head of Language Department, Michigan College of Mining and Technology, Houghton, Mich. J. M. Harrington, H. B. Anderson.

GRAFFIUS, PAUL H., Engineering Personnel Representative, Lockheed Aircraft Corporation, Marietta, Ga. R. L. Sweigert, B. W. Boguslavsky.

HAUSRATH, A. H., III, Assistant Professor of Engineering, Research Laboratory, Pennsylvania State University, State College, Pa. G. Murphy, W. L. Collins.

HAWK, MINOR C., Assistant Professor of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. D. W. Ver Planck, J. W. Graham.

HEARTZ, FREDERICK R., Assistant Professor of Civil Engineering, South Dakota State College, Brookings, So. Dak. E. E. Johnson, W. H. Gamble.

HEMMERT, RAYMOND A., Assistant Professor of Mechanical Engineering, Tri-State College, Angola, Ind. J. C. Humphries, R. A. Hockey.

HINRICHSEN, JOHN J. L., Professor and Head of Mathematics Department, Iowa State College, Ames, Iowa. H. J. Gilkey, H. M. Black.

HOLCOMB, WALTER W., Instructor in Mechanical Engineering, Tri-State College, Angola, Ind. J. C. Humphries, P. A. Nurnberger.

HORAK, GEORGE C., Assistant Professor of Mining and Metallurgy, Lafayette Col-

lege, Easton, Pa. C. N. Truax, Jr., L. D. Clark.

HOUGHTON, JAMES E., Instructor in Engineering Drawing, University of Notre Dame, Notre Dame, Ind. L. Daniel, H. P. Ackert.

ITO, SEIWA, Assistant Professor of Engineering, Hokkaido Gakugei University, Iwamizawa Br., Iwamizawa, Hokkaido, Japan. T. Onodera, T. Watanabe.

KEHO, CLIFF H., Assistant Professor of Civil Engineering, Valparaiso University, Valparaiso, Ind. H. C. Hesse, C. E. Peller.

KEITH, CHARLES, Instructor in Industrial Arts, Kent State University, Kent, Ohio. P. E. Machovina, R. S. Paffenbarger.

KELLY, FREDERICK L., JR., Instructor in Engineering Drawing, University of Alabama, University, Ala. J. A. Bennett, W. H. Taylor.

KIPP, JOHN E., Instructor in Applied Mechanics, University of Kansas, Lawrence, Kansas. T. V. Nemecek, K. C. Deemer.

LOVERIDGE, LAWRENCE E., Instructor in Physics, Newark College of Engineering, Newark, N. J. A. J. Manock, M. R. Weller.

MANTELL, CHARLES L., Professor of Chemical Engineering, Newark College of Engineering, Newark, N. J. G. B. Thom, G. C. Keefe.

MARBOE, ROBERT F., Manager of Engineering Services Division, Ordnance Research Laboratory, Pennsylvania State University, State College, Pa. A. Addison, A. T. Thompson.

MARTIN, GEORGE H., Lecturer in Mechanical Engineering, Northwestern University, Evanston, Ill. R. L. Young, D. D. Kilner.

MCGLOTHLAN, JOHN A., Instructor in Mechanical Engineering, University of Denver, Denver, Colo. W. Parks, A. Krill.

MORTIMER, KENNETH, Associate Professor of Civil Engineering, Valparaiso University, Valparaiso, Ind. H. C. Hesse, C. E. Peller.

NELSON, HANS P., Instructor in Engineering Drawing, Wayne University, Detroit, Mich. R. T. Northrup, R. W. Grant.

PAN, SAI-LUNG, Assistant Research Professor of Civil Engineering, Manhattan College, New York, N. Y. O. Ondra, Brother J. McCabe.

PERRON, CHARLES H., Assistant Instructor in Civil Engineering, Newark College of Engineering, Newark, N. J. W. S. LaLonde, Jr., J. M. Robbins.

PUGH, WALTER H., Instructor in Engineering, Pittsburgh Technical Institute, Pittsburgh, Pa. B. R. Teare, Jr., J. R. Jackson.

RAMSAUR, JOHN C., Instructor in Mechanical Engineering, Louisiana Technical Institute, Ruston, La. L. R. Daniel, Jr., J. G. Chumley.

RENOUD, HARRY R., Head of Mathematics Department, Reedley Junior College, Reedley, Calif. B. M. Green, H. H. Wheaton.

RISSER, ARTHUR C., Assistant Professor of Engineering Drawing, University of Wichita, Wichita, Kans. M. H. Snyder, Jr., J. W. Dunn.

RYSKIEWICH, BERNARD S., Instructor in Engineering Drawing, New York University, New York, N. Y. I. Wladever, L. O. Johnson.

SHANAHAN, ROBERT J., Assistant Professor of Engineering Drawing, University of Notre Dame, Notre Dame, Ind. H. P. Ackert, W. W. Turner.

SHERRILL, ALVAN C., Assistant to Works Manager, Columbia-Southern Chemical Corporation, Barberton, Ohio. H. O. Croft, A. A. Pringle.

SHEWAN, WILLIAM, Assistant Professor of Electrical Engineering, Valparaiso University, Valparaiso, Ind. H. C. Hesse, C. E. Peller.

SHIRK, RICKLEF, W., Staff Assistant, Chrysler Institute of Engineering, Detroit, Mich. W. L. David, L. R. Baker.

SMITH, HENRY H., Assistant Professor of Physics, Newark College of Engineering, Newark, N. J. A. J. Monock, M. N. Mainardi.

SMITH, PHILIP A., Professor of English, Rensselaer Polytechnic Institute, Troy, N. Y. F. Abbuhl, S. P. Olmsted.

SPERRY, CLAUDE J., JR., Assistant Professor of Electrical Engineering, Tulane University, New Orleans, La. C. W. Ricker, D. H. Vliet.

SWIFT, ROBERT G., Engineering School Supervisor, Bell Telephone Company of Pennsylvania, Philadelphia, Pa. J. G. Brainerd, S. R. Warren.

UBAN, EARL C., Assistant Professor of Civil Engineering, Valparaiso University, Valparaiso, Ind. H. C. Hesse, C. E. Peller.

URBAN, MOSES W., Professor of Mechanical Engineering, Valparaiso University, Valparaiso, Ind. H. C. Hesse, C. E. Peller.

WARNICK, CALVIN C., Associate Research Professor of Civil Engineering, University of Idaho, Moscow, Idaho. L. B. Craine, D. S. Hoffman.

WETTERSTROM, EDWIN, Assistant Professor of Civil Engineering, University of Missouri, Columbia, Mo. M. M. Bolstad, R. H. Luebbers.

WILLIAMS, J. FRED, JR., Associate Professor of Metallurgical Engineering, State College of Washington, Pullman, Wash. J. P. Spielman, C. L. Baker.

322 new members elected this year

In the News

The **National Academy of Sciences-National Research Council** has been asked by officials of both industry and Government to establish within the Academy-Research Council framework a committee to concern itself with the common interests and relationships of industrial and governmental research, particularly in the area of applied research.

Conferences between industrial and governmental research executives and directors, called by the Academy-Research Council, recommended that a small committee be organized to explore the need for better acquaintance and understanding between Government and industry research leaders, and to consider methods for accomplishing this objective. As a result, the Government-Industry Research Committee has been organized by the Academy-Research Council with the following membership:

Edgar C. Bain, United States Steel Corporation, Chairman
Allen V. Astin, National Bureau of Standards
D. P. Barnard, Deputy Assistant Secretary of Defense, Research and Development
Ralph Bown, Bell Telephone Laboratories, Inc.
Ralph Connor, Rohm and Haas Company
Hugh L. Dryden, National Advisory Committee for Aeronautics
Paul D. Foote, Gulf Research and Development Company
G. E. Hilbert, Agricultural Research Service, U. S. Department of Agriculture
Randolph Major, Merck and Company, Inc.
Roy C. Newton, Swift and Company
Alan T. Waterman, National Science Foundation

At its first meeting the Committee concluded that effective mechanisms already exist in many fields for furthering mutually helpful relations between government and industry research. However, the Committee agreed to hold itself available as necessary to assist in exchanging views and ideas designed to improve such relations where either Government or industry groups may feel this to be desirable.

When its services are requested, the Committee proposes to consider first the extent to which the need can be satisfied by existing mechanisms. If appropriate, the Committee will then consider designation of an *ad hoc* group of individuals active in the particular field concerned to assist in bringing about improved understanding and closer relationships between Government and industry people in that field.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 29–30, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 7, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Swarthmore College	May 7, 1955	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	March 26, 1955	M. M. Jones, University of Missouri
National Capital Area	Catholic University	Oct. 5, 1954	J. C. Michalowicz, Catholic University
New England	Massachusetts Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	A.F. Inst. Wright	Sept. 17–18, 1954	K. F. Sibila, University of Akron
	University of Akron	May 7, 1955	
Pacific Northwest	University of Idaho	April 15–16, 1955	M. L. Jackson, University of Idaho
Pacific Southwest	University of California, Berkeley	Dec. 28–29, 1954	B. M. Green, Stanford University
Rocky Mountain	Colorado A. & M. College	April 16, 1955	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9, 1955	V. L. Doughtie, University of Texas
Upper New York	Cornell University	Oct. 22–23, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTOR IN ELECTRICAL ENGINEERING on or before February 1, 1955: One familiar with electric power and electronics; preferably some industrial experience. Good opportunity for advancement. Franklin Technical Institute, 41 Berkeley Street, Boston 16, Mass.

AN INSTRUCTOR IN ENGINEERING Drafting and Machine Design on or before February 1, 1955: One thoroughly familiar with theory and practical design who has had some industrial experience. Opportunity for advancement. Franklin Technical Institute, 41 Berkeley Street, Boston 16, Mass.

ASSISTANT PROFESSOR—TO TEACH Dynamics, Fluid Mechanics, Vibrations, engineering analysis. At least a master's degree and some industrial experience preferred. Apply to Louis Slegel, Department of Mechanical Engineering, Oregon State College, Corvallis, Oregon.

INSTRUCTOR IN MECHANICAL ENGINEERING to teach Laboratory and Lecture courses in the Heat-Power field. Start now or later. Salary depends on qualifications. Apply to: Prof. J. W. Bunting, Department of Mechanical Engineering, University of Cincinnati, Cincinnati 21, Ohio.

INSTRUCTOR FOR INDUSTRIAL ELECTRONICS Department of a New England Technical Institute. B.S. Degree with industrial or teaching experience desired. Position open September 1, 1955. Apply to: Head, Industrial Electronics Department, Wentworth Institute, Boston, Mass.

ENGINEERING TEACHERS. ELECTRICAL—Circuits, Machines, Electronics. Civil—surveying and strength of materials. Mechanical—thermodynamics and heat-power. Drawing—drawing, descrip. geom., and design. M.S. degree plus industrial experience reqd. Excellent opportunities in young department for instructor or assistant professor with interest in teaching. New bldg. and equipt. Good salary scale. San Jose State College, San Jose, California.

RESEARCH ASSISTANTS AND INSTRUCTORS (part-time and full-time) for teaching and research in Engineering Mechanics. Opportunity to study for the M.S. or Ph.D. degrees. Apply to: Professor J. Marin, Head, Department of Engineering Mechanics, The Pennsylvania State University, State College, Pennsylvania.

ACTING HEAD OR HEAD, CIVIL ENGINEERING. Familiar with current undergraduate curricula and cooperative plan. Prepared to teach Soil Mechanics, Structures and Surveying. Twelve month appointment open September, 1955. Address Dean of Engineering, The University of Akron, Akron 4, Ohio.

CHRYSLER INSTITUTE OF ENGINEERING

again has openings on its full time teaching staff. They are:

1. Supervisor of engineering graduates working on individual automotive design projects as a part of their Graduate School course. Duties would also include supervision of graduate classwork.

   Desired qualifications: Age 25–40; BS degree or higher in engineering; at least 2 years of college teaching experience; some design experience, preferably automotive.

2. Teacher and supervisor of Graduate School classwork. Qualifications: Age 25–40; MS degree in engineering; experience in teaching mechanical engineering subjects.

Please write to—

CHRYSLER INSTITUTE OF ENGINEERING
Attn: L. R. Baker, Director
P. O. Box 1118
Detroit 31, Michigan

ASEE Catalog of Learning Aids

Civil Engineering — Electrical Engineering

Mechanical Engineering — Engineering Mechanics

Mathematics

Prepared by the ASEE Committee on Teaching Aids. Over 5000 teaching aids have been reviewed. The catalog lists 290 aids which are rated by the ASEE reviewing committees as the best available learning aids for engineering education. The catalog summarizes the content of each aid, recommends the course for which it is best adapted, gives details of physical size, equipment necessary, where it can be obtained, cost and other pertinent data.

This catalog will direct you by the most expeditious route to those teaching aids which will add a new dimension to your teaching. Send for one today.

This project was financed by contributions from industry to defray the traveling expenses of the reviewing committees and to make it possible to carry this on as a continuing project of ASEE.

Send remittance to

Price $1.00

American Society for
Engineering Education,
University of Illinois,
Urbana, Illinois

College Notes

Colleges and universities throughout the country have been invited by the **University of Minnesota** to send delegates to the Second National Conference on Campus Safety to be held at the University April 18–20, 1955. At the first conference, held last year at the University of Illinois, 28 institutions from various parts of the country were represented.

The conference is aimed at a nation-wide exchange of ideas on specific problems to be met in promoting the safety of students and employees. "Fire Safety" will be discussed by Professor John J. Ahern, Illinois Institute of Technology. Fred R. Ingram of University of California will treat campus occupational health problems. Professor William E. Cox of Georgia Institute of Technology is scheduled to talk on the integration of safety into the general curriculum.

Safety standards for off-campus housing, protecting one-third of the University of Minnesota's 20,000 students, will be described by Richard G. Bond of the Students' Health Service of the University. The part of sound architecture in the safer campus will be handled by Otto Teegan, State University of New York. Other talks will concern traffic safety and parking problems, intramural athletics, radiation safety, shop and laboratory areas, and the special problems of the agricultural campus.

The conference is sponsored jointly by the University of Minnesota and the National Safety Council. All sessions will be held on the Minneapolis campus, at the Center for Continuation Study, a self-contained college with complete conference facilities, including eating and sleeping accommodations.

As a part of the Centennial Year celebration at **Michigan State College**, the College of Engineering is sponsoring a symposium on the topic, "Automation —Engineering for Tomorrow" on May 12–14, 1955. The program is designed to attract engineers, executives, educators and others interested to the campus. In order to appeal especially to practicing engineers with specialized interests, separate programs for the several branches of engineering have been planned, with all of the groups meeting together for certain general sessions. Professor J. M. Apple is Chairman of the symposium.

The Ninth Annual Industry-Faculty Conference at **Louisiana State University** will be held March 31–April 1, 1955. The theme of the conference this year is "The Engineering School, the Engineer and Industrial Development." Speakers at the conference will include Dean N. W. Dougherty, ASEE President; Mr. J. N. Gorringe, Esso Standard Oil Co.; Dr. Frank Soday, Chemstrand Corp. For further information write to J. W. Brouillette, Director, General Extension Division, Louisiana State University, Baton Rouge 3, La.

ANNUAL MEETING

June 20-24, 1955

Pennsylvania State University

STATE COLLEGE, PA.

Do You Know—

► Tear this page out and take it home to your wife and family!

► The Annual Meeting is at Penn State, State College, Pennsylvania, June 20–24, just as you have been hearing for a long while. However, you should know the institution's full name is The Pennsylvania State University and that the name of the city recently has been changed to *University Park*. So whether you are urged to go to State College or University Park, Pennsylvania, you will get to the Annual Meeting.

► The folks at Penn State are saying they are located in the "vacation land" portion of the state and have planned interesting events for the ladies. The Reading Room and Studio of the Hetzel Union Building will be open all week. There is a Welcoming Tea on Monday, trip to Penn's Cave followed by a Pennsylvania Dutch luncheon, a bridge luncheon at Centre Hills Country Club, a trip to nearby historic Boalsburg for their annual festival, and an illustrated lecture on the Amish in Pennsylvania.

► Adequate plans are also being made for the young folks. The University Nursery School will be available with experienced nursery-school teachers for children age three to six. The fee for the entire period is $3.00. See the Preliminary Program for more details.

For children six to eleven daily programs of games, crafts, picnics, swimming, etc., are planned.

The teen-agers also have their special events—get acquainted party, all day picnic and swimming at Whipples Dam, dancing, games, roller skating and, lastly, a farewell party at which tournament prizes will be awarded.

► The closed conference on Thermodynamics, jointly sponsored by ASEE and NSF, was held at Purdue University on February 28 and March 1. Almost all of the discussions pertained to the open *Conference on Thermodynamics in Engineering Education* to be held at Penn State on June 27–29. It was agreed that the Conference should be aimed at young teachers of engineering thermodynamics and the program developed centers around some of the aspects of thermodynamics which are having an impact on engineering and engineering education. Some of the speakers who already have accepted are Matt Souders, G. A. Hawkins, Newman Hall, M. Zemanski, Samuel Glasstone and Henry Eyring. For detailed information write to W. E. Ranz, Associate Professor of Engineering Research, The Pennsylvania State University. Registration is limited to 125 persons.

► The joint meeting of the Relations with Industry Division and the Iowa Engineering Society at Des Moines, Iowa, on March 1 and 2, was a rousing success. Over 500 attended the well-planned two-day program. The Advisory Committee and the Executive Committee of the Division each held a meeting and on the second day the joint session program theme was "Current Problems Facing the Engineering Profession." Professionalism, unionism, and unity were discussed. At the Annual Banquet our President, N. W. Dougherty, spoke enthusiastically and interestingly on "Today Is Not Midway Between Yesterday and Tomorrow." Even the ladies were enthusiastic! The President hasn't announced the title of his annual address, but if the RWI speech was a sample, be sure to plan on hearing President Dougherty at Tuesday's General Session of the Annual Meeting.

► The English Division has mailed out its notice and program for its Summer School at Penn State, June 24 and 25. They hope to promote a fruitful exchange of facts and views between the English and engineering members of faculties and between administrators and classroom teachers. The program speakers are R. W. VanHouten, President, Newark College of Engineering; J. L. Vaughan, University of Virginia; W. D. McIlvaine, Jr., University of Alabama; Douglas Washburn, Rensselaer Polytechnic Institute; Frank Kerekes, Michigan College of Mining and Technology; W. G. Crouch, University of Pittsburgh.

► *Here is how to get to Penn State.*

By highway, the intersection of highway routes US 322 and Penna. 45.

By bus, the Greyhound Bus Lines from Pittsburgh, Harrisburg or Scranton and the Edwards Bus Line from Elmira, New York (by way of Williamsport, Penna.) and from Cleveland, Ohio.

By train, the Pennsylvania Railroad: from the west to Altoona, Penna., and then by Greyhound Bus Lines (42 miles); from the east to Lewistown, Penna., and then the Boalsburg Bus Line (30 miles). To avoid excessive delay between train arrival and bus departure, schedule arrival at Lewistown or Altoona to coincide with the bus schedule.

By air, the Allegheny Air Lines from Pittsburgh and Newark to Mashannon airport and then a taxi (25 miles) to State College (University Park).

► Mimeographed copies of the Preliminary Program for the Annual Meeting were mailed on March 4, to all chairmen responsible for programming. As soon as the corrections and additions are received a copy goes to Lancaster Press. Then, as soon as printed, the programs are mailed to all of you by Lancaster Press; the registration, housing and special events cards will be enclosed with the programs.

► For information on Summer Schools to be held at Penn State write to:

Chemical Engineering Teachers
(June 27–July 2)

Dr. K. H. Kobe
Chemical Engineering Department
University of Texas
Austin 12, Texas

Thermodynamics Conference
(June 27–29)

Dr. W. E. Ranz
Associate Professor of Engineering Research
The Pennsylvania State University
University Park, Penna.

English
(June 24 and 25)

Dr. G. J. Christensen
Department of English
Lehigh University
Bethlehem, Penna.

► The Constitution of the Society provides for the election of the President, two Vice Presidents and Treasurer at each annual meeting by ballot of the individual membership present. The Nominating Committee consists of the three Junior Past Presidents and the General Council members elected by Sections and Divisions whose terms expire this year. Members of the Society are requested to submit names to be considered to the Secretary by April 20. The names then will be submitted to all members of the Nominating Committee.

The Vice President to be elected this year, for two years, is the Vice President in charge of Instructional Division Activities. The Second Vice President to be elected is the chairman of ECAC, who is elected to that office by the ECAC membership and automatically becomes a Vice President of the Society. A nomination blank may be found on page 477 of the January issue of the *Journal.*

W. LEIGHTON COLLINS
Secretary

Looking Ahead

By ARTHUR BRONWELL

President, Worcester Polytechnic Institute and Past Secretary of ASEE

In recent years the ASEE has undertaken numerous projects, cutting across all of engineering education, which are destined to have far-reaching influence upon the future of engineering education. These achievements are a high tribute to the enthusiasm and devoted service of many hundreds of educational leaders who have participated in the work of the Councils, Divisions, Committees, Sections and Branches of the Society. Through their efforts there has been stimulated a vigorous and constructive outlook toward engineering education which has permeated practically every engineering college of the country. Attitudes of complacency and self-satisfaction with the status quo have been supplanted by a spirit of challenge and inquiry, which penetrates to the very foundations of engineering education.

Engineering education has always been in transition. In the past, we have seen how broad areas of engineering practice have grown from toddling infancy to giant industries in a comparatively short period of time. Not many years ago, such fields as aeronautics, electronics, chemical engineering, metallurgy, and engineering mechanics were the barbaric renegades trying to get faint recognition in the engineering curricula. Today they have earned distinctive places in the curricula and have not only contributed to the rapid development of their own professional fields, but they have also illuminated the more traditional fields with new fundamental concepts and new methods of analysis.

Today the frontiers of science and engineering are advancing at a more rapid pace than at any time in history. This geometrical growth of knowledge is continuing to open up whole new domains of fundamental knowledge which will revolutionize engineering practice of tomorrow just as assuredly as the growth of knowledge over the past quarter of a century has revolutionized engineering practice of today. This growth of knowledge presents vital challenges to engineering education. The new developments must constantly be critically examined and assessed as to their importance. When engineering education fails to be responsive to the advancing needs of the times, then our education and our industry will be well along the road to stagnation.

The ASEE project on Evaluation of Engineering Education, under the able leadership of Dean Linton Grinter, will present its final report at the Annual Meeting in June. This project, which enlisted the active participation of committees in over 120 engineering colleges throughout the country, has stimulated a vigorous and penetrating re-examination of all phases of engineering education. It has pointed the way toward a highly successful type of cooperation between faculty members in engineering colleges and ASEE committees.

The Humanistic-Social Research Project, under the direction of Dr. George Gullette, has already made substantial gains during its first year of operation. Its field committees are investigating educational programs in engineering colleges throughout the country. The visitation committees are seeking those programs which show fresh and imaginative

approaches and which hold promise of making substantial contributions to the teaching of the humanities and social sciences. This evidence will be reviewed by a committee of ASEE under the Chairmanship of Dr. Edwin Burdell and recommendations will be drawn up for improvement of education in this important area of the curriculum. The visitations of the field committees have provided a constructive influence in compelling engineering colleges to assess their own programs in these areas. The final report of the Committee will probably be presented in June 1956.

The Committee on Ethics has published in the Journal its preliminary report, recommending means of inculcating ethical concepts in our educational programs. The Committee's Chairman, Dean Clement Freund, is now working effectively with administrative officers in engineering colleges in an endeavor to get much needed recognition for this area of educational responsibility.

A proposal has just been drawn up for a project to investigate some current problems and policies relating to graduate study. The growing importance of graduate study and the many divergent viewpoints on complex problems in this area of engineering education serve to emphasize the significance of this project. It is hoped that the project, to be conducted by the Graduate Studies Division, can get under way with adequate financing this year.

Several years ago the Society completed two highly significant reports. One was on Improvement of Teaching and the other a Graduate Manual, dealing with the objectives and policies of graduate study. Both reports, prepared under the Chairmanship of Dr. Grinter, have been in heavy demand and have received high acclaim from the Society membership.

What Are The Challenges Ahead?

The foregoing studies have provided critical analyses in the dominant areas of engineering education. But what are the challenges which lie ahead? First there is the essential problem of carrying forward the study on Evaluation of Engineering Education into the individual curricular areas. The central committee of the Society could only define the broad objectives of the study—it could not make detailed investigations into each of the curricular areas. This is the problem which challenges the Divisions of the Society. It is their responsibility to project ahead with bold and imaginative thought to analyze the various alternatives to the present curricular structure and present their recommendations for constructive experimentation along soundly-conceived lines.

Second, it seems highly desirable to bring the reports of the various projects together into a bound volume, representing the current thinking on engineering education. Funds for such a project could undoubtedly be obtained from industry or from one or more foundations. Such a volume would contain the reports on Improvement of Teaching, Evaluation of Engineering Education, the Humanistic-Social project, the Graduate Studies project, the Graduate Manual and Ethics. It might also include individual reports prepared by the Divisions of the Society respecting their curricular areas. Such a composite volume would be of inestimable value to engineering educators in the years ahead.

Other significant areas of ASEE operation in recent years have included preparation of a bulletin on teaching aids, the inauguration of a Summer Institutes program and the expansion of the ASEE Summer School program.

The Teaching Aids bulletin, just completed, lists the best 290 teaching aids out of 5000 which were reviewed by Committees. This bulletin will be exceedingly helpful to engineering teachers in selecting the most effective teaching aids for engineering courses. The Committee, under the Chairmanship of Professor Carl Muhlenbruch, reviewed teaching aids

in five of the curricular areas. This project might well be extended into other curricular areas in the years ahead.

The Summer Institute program, inaugurated last year, brings together leading educational and research authorities for conferences in specific areas where there is promise of making substantial progress in engineering education. Last year's Summer Institutes dealt with Solid State Physics and Nuclear Engineering, two areas which are already making substantial inroads into engineering practice. Two additional Summer Institutes, one on Thermodynamics and another on Advanced Mathematics in Engineering, will seek out methods of unifying subject matter which is now presented from entirely different viewpoints in different curricular fields. The proceedings of these conferences will be published to disseminate the information as widely as possible. Such conferences, where leading authorities in a given field tackle a specific problem of great significance to education, can effect substantial progress in a comparatively short period of time, as compared with the slow trial-and-error method of the past.

The Summer School program has been greatly expanded during the past five years. Last year there were five Summer Schools with an attendance exceeding 450. This Summer School program has been an invigorating and dynamic influence in keeping engineering education moving ahead in response to the challenges of the times.

One of the most encouraging developments in ASEE in recent years has been the spontaneous growth of the Young Engineering Teachers movement. The YET's have developed their own activities and expanded their numbers with great vigor and enthusiasm. Active participation of young engineering teachers in ASEE affairs broadens their perspective on engineering education and improves their teaching competence. It enables them to become acquainted with their colleagues in other colleges and thus provides that vital stimulation which increases their interest in engineering education.

A recent analysis of ASEE membership records indicates that approximately 20% of the Society members are below 36 years of age. This is a truly remarkable tribute to the enthusiastic promotion which the YET's have given their movement. With further encouragement and ample opportunities to develop their own activities, this movement can grow into very substantial proportions in the years immediately ahead. It is one of the most promising developments of ASEE.

Another highly encouraging development has been the growth of relationships between the ASEE and industries throughout the country. Under the imaginative leadership of Jesse McKeon, over 120 large companies have been added to the ASEE Associate Institutional membership roles. The Division of Relations With Industry has always had a vigorous and constructive program dealing with relationships between industry and engineering colleges. This relationship is of growing importance in view of industry's desire to provide financial assistance to engineering colleges. The Associate Institutional Membership program should be promoted vigorously in the years ahead. It can yield very substantial returns, both to engineering education and to industry.

The activities of ECRC and ECAC in their respective areas of operations, dealing with research and administrative policies of engineering colleges as well as with their relationships with industry and government, have provided a valuable service to the colleges. The publication of the Directory of Research, listing research projects in engineering colleges throughout the country; the studies on the supply and demand of engineering manpower; the studies of ROTC problems; and the many other helpful services of these Councils have been exceedingly valuable to administrators of engineering colleges.

It has been gratifying to know that the principal engineering societies, the engineering profession and industry have all been solidly behind ASEE during this rising tide of ASEE activities. The contributions of $12,000 from the constituent societies of ECPD and the Engineering foundation and of $20,000 from the General Electric Company have been of inestimable value in the project on Evaluation of Engineering Education. The Carnegie Corporation's grant of $30,000 for the Humanistic-Social Project, the National Science Foundation's grants of $15,500 for the Summer Institutes, and the industrial grants for the Teaching Aids program and other ASEE projects all attest to the constructive support which the Society has been privileged to receive. Our experience has shown that industry and philanthropic foundations stand ready and willing to provide financial assistance for well-conceived projects which the Society might desire to undertake.

Unfinished Business

There is one matter of unfinished business which I would urge that the General Council take up at its meeting this June. It has been repeatedly pointed out that the Executive Boards of the Society have for a number of years consisted exclusively of engineering deans (except for the Treasurer and Secretary). The reason why deans are selected rather than college professors is quite evident. Deans are better known and usually have had broader administrative experience than college professors.

But I think that the request that a procedure be established to assure that at least one member of the Executive Board (other than the Treasurer or Secretary) comes from professorial ranks, is an entirely valid criticism. This can be achieved in either one of two ways. One procedure would be to compel the Nominating Committee to maintain at least one professor on the Board. This is probably the simplest solution, but I think that it is a highly undesirable one for reasons which I shall try to set forth.

Each year two new vice presidents are added to the Executive Board, one being selected by the Nominating Committee and the other by either the ECRC or ECAC. On the average one of these two vice presidents will eventually become President of the Society. Now I think that it is exceedingly important that the Nominating Committee have an ample pool of talent to draw from in selecting the President. For the most part, they will probably want to select a dean or other administrative officer for President because of his administrative experience. It seems highly undesirable, therefore, to erect barriers which will deliberately block the way of deans getting to the Executive Board.

There is another approach which I believe is a more satisfactory solution to the problem. This would be to create a new position on the Executive Board, to be open only to a person of professorial rank. This person would be elected by the General Council from among their own ranks.

From an organizational viewpoint, there is a very valid reason for creating a new post on the Executive Board. At present the Vice President in charge of Divisions and Committees has jurisdiction over about 35 different Divisions and Committees of the Society. During my eight years as Secretary, no vice president has ever attempted to maintain consistent contact with more than seven or eight of these units. It is a generally accepted principle in organization that no one administrator should have more than about six or seven people reporting to him. While this principle might not apply in its entirety to an organization such as ASEE, it is clearly beyond reason to expect a vice president to maintain active and helpful contact with 35 different units. The fact that no vice president in the past eight years has done this bears out the inadequacy of the present organization.

Briefly, the proposal then is as follows. The General Council at its meeting in June would establish a new post on the Executive Board, with appropriate title and duties as specified by the Council. The Council would elect from among its own constituency a person of professorial rank to fill this post. The term of office would be two years, the same as that of a Vice President. All of this can be accomplished without a Constitutional amendment. At some convenient time in the future, the Constitution could be amended to give this post the title of Vice President and to specify in the Constitution the duties associated with the position. The foregoing procedure would provide a helpful period of experimentation before amending the Constitution.

During the past eight years, the Society has faced serious financial problems. A vigorous membership campaign doubled the Society membership and a campaign to expand advertising in the *Journal* substantially increased revenue from this source. The Associate Institutional membership campaign also added additional revenue. But inflationary costs in the post-war period and the expanded services of ASEE have resulted in continued financial problems. The modest increase in dues voted by the Society membership last year has solved the financial problems and it now seems evident that the Society has adequate finances for a high level of achievement.

In recent years, the Society has taken an active role in affairs of the Engineers' Joint Council, ECPD, the American Council on Education and other organizations which represent the collective efforts of the engineering and educational professions. Many of the constructive programs of these organizations have been initiated by our ASEE representatives. Dean Thorndike Saville, the ASEE representative to the Engineers Joint Council, is in his second year as its President. It is exceedingly important that ASEE cooperate fully with other major engineering societies in these joint endeavors which are becoming so important to the engineering profession.

A Word of Appreciation

It has been a great privilege and pleasure to have had the opportunity to serve as Secretary of ASEE during the past eight years. It has been a period of rising crescendo in ASEE activities —of new challenges and opportunities. Through the development of plans of mutual participation, the attention of faculty members in engineering colleges throughout the country has been focused upon ASEE activities and we have received great help and encouragement from them. It has been particularly rewarding to have had the privilege of working with the officers of the Society. Their enthusiastic support of the Society's work and tireless devotion to duty have always been a source of great encouragement.

Although the principal projects of the Society are of necessity the focal points of attention, it is in the Councils, Divisions, Committees, Sections and Branches of the Society, providing as they do a national forum for the discussion of the diverse problems on engineering education, that new ideas are brought to focus and trends established. The forward-looking programs of these groups within the Society have done much to keep engineering education moving abreast of the needs of the profession. I should like to take this opportunity to add my expression of personal gratitude for the excellent cooperation and constructive help which we have received from the officers of these groups.

Also, I wish to express my deep gratitude to the members of the office staff, particularly to the office Executive Secretary, Marion Strohm, and to the Assistant Secretary and Editor of the *Journal*, Professor Watson, for their years of devoted service. The ASEE headquarters has been seriously understaffed until recently, when the dues amendment made it pos-

sible to bring the secretarial staff up to a reasonable level. The faithful and devoted service of our headquarters staff, often operating under trying conditions and heavy overloads, has been a constant source of confidence and inspiration to me.

The Society is extremely fortunate in its choice of Professor Collins as its new Secretary. He is an educator of considerable stature and has taken active part in many ASEE affairs. At the time of his election as Secretary, he was a member of the General Council. May I urge you to give him the same enthusiastic support and wholehearted cooperation which we have enjoyed during the past eight years.

Centennial Engineering Symposium

Michigan State College, the first of the land-grant colleges in the United States, commemorates its Centennial this year. For its contribution to the Centennial program the School of Engineering is sponsoring on May 12 and 13, 1955, the sixth of a series of ten academic symposia as a means of focusing attention on automation, one of the most important developments in its entire field of engineering. This Centennial Engineering Symposium is planned to be one of broad, national interest with programs built around a series of general sessions of interest to all branches of engineering and a concurrent series of meetings sponsored by the seven individual departments of the school.

The general symposium theme will be "Automation—Engineering for Tomorrow." This latest and powerful tool of the engineer, which is having an increasing impact on the lives of all Americans, will be surveyed from its lowly beginnings through its present accelerating and far-ranging development to its unlimited future potentialities in the decades to come. General sessions held in the morning of May 13 will be devoted to presentation of two topics for discussion, "Automation—To Date" and "Development of Automatic Production Facilities." Important luncheon and banquet speakers will be Dr. W. R. G. Baker, Vice-President of the General Electric Company, and Dr. Eric A. Walker, Dean of Engineering at Pennsylvania State University. Dr. Baker will speak on "Automation as an Engineer Sees It," developing his subject from the technical point of view. Dean Walker will discuss "Automation—A Look into the Future" from the philosophical or sociological point of view.

In the afternoon of May 13 each department of the School of Engineering, including those departments holding a more comprehensive two-day meeting, will sponsor its own concurrent series of meetings on those special themes of automation which will be of considerable interest to men in its particular field. These meetings will present as speakers many well known designers and engineers in widely diversified fields. Talks, discussions and panel sessions will be conducted by these leading authorities. Participation by representatives of national and state professional associations, societies and manufacturing groups is assured.

Report of the Joint Committee of the American Society for Engineering Education and the Mathematical Association of America on Engineering Mathematics

This Committee was appointed in the fall of 1953 and charged with:

1. Consideration of how mathematics can be taught in the most effective way for engineers;
2. Acting as liaison between ASEE and the MAA;
3. Keeping in close contact with the MAA Committee on the undergraduate mathematical program under the Chairmanship of W. L. Duren.

The matter of liaison and of keeping in contact with Duren's committee has been effected in the following ways. The first meeting of the Committee was in Baltimore on December 30, 1953 in conjunction with the annual meeting of the MAA. The second meeting of the Committee took place in Urbana on June 17, 1954 at the annual meeting of the ASEE. The MAA Committee on the Undergraduate Program was represented at our first meeting by W. L. Duren and at the second by G. B. Price. At the invitation of R. S. Burington, Chairman of the Mathematics Division of the ASEE, Price also presented to the Division a report on current efforts to revise the undergraduate program in mathematics.

The liaison between the MAA and the ASEE is probably best maintained through the Mathematics Division of the ASEE. Mathematicians engaged in teaching engineers should be encouraged to join and to support the activities of both the ASEE and the MAA. Continued publicity about the activities of the Mathematics Division of the ASEE in the *Monthly* should be encouraged.

Mathematics for Engineers

The Committee has directed its attention to the following three questions in this connection.

1. What mathematics should be taught?
2. Who should teach it?
3. How should it be taught?

What Mathematics should be taught to engineering students? This question is the subject of study and debate from many sides.

The ASEE's Committee on Evaluation of Engineering Education in its Interim Report of June 15, 1954 (p. 10) states: "At the undergraduate level, competence in the theory and use of simple ordinary differential equations and their application to the solution of physical problems lies close to the boundary of minimum acceptability of mathematics in any satisfactory engineering curriculum. For students whose interests will be centered in research, development, or the higher phases of analysis and design, or who contemplate subsequent graduate study in engineering, additional mathematics may be both desirable and necessary."

The MAA's Committee on the Undergraduate Mathematics program has endeavored to formulate a first year mathematics course which would "try to incorporate into collegiate mathematical teaching the valuable results of modern researches in mathematics and logic and to eliminate that which is unnecessary or

faulty." While they have in mind a program for *all* students who study mathematics in college, they are thoroughly aware of the fact that "the revision must concentrate upon the needs of the vast majority ('95 percent') of students who take mathematics to increase their powers for solving problems and grasping the ideas of science. Thus the approach to mathematics at this stage (i.e., during the first two years of college) shall be *operational* rather than merely *appreciative.*" They are experimenting with, and currently engaged in writing text materials for, a basic three-hour course for all students who take mathematics for the first year. In the first semester this would take up: graphs; functions; limits; introductory calculus based on polynomials, exponentials, and logarithms. The material in the second semester would include: sets, mathematical language, groups, combinatorics, distributions, approximate sums, probability. The basic course would be supplemented for engineering and physical science students with a two-hour course as follows:

First semester

Numerical trigonometry, graphical analysis, Newton's methods, numerical integration, tables of logarithms and exponential functions, slide rule, log and semilog paper, rate problems.

Second semester

Worded problems, binary representation, computing machines, centroids and moments of inertia, averages, precision in measure and computation, finite differences, tables of normal probability, density, sampling.

For engineering students, this would be continued in the second year into a course in calculus and analytic geometry with geometric and mechanical applications using vector methods, which would also include linear differential equations with constant coefficients. The program has been tried, with success, at Tulane.

There are other experimental mathematics programs being tried at the University of Washington, Haverford College, Carleton College, The Illinois Institute of Technology, Brown University, Yale, and no doubt at many other institutions.

High School Preparation

So far as the undergraduate curriculum in engineering is concerned, the crucial question seems to be "how much useful mathematics can be taught to the engineers in the time now allotted to mathematics in the undergraduate curriculum?" The answer to this question obviously depends upon the previous mathematical preparation of the entering freshmen. Where this preparation is meager, it is now customary for the students to take college algebra, trigonometry, and analytic geometry in the freshman year and to follow this with a course in calculus in the sophomore year. Where the high school preparation includes trigonometry as well as a strong background in algebra, it is possible to give a combined course in calculus and analytic geometry beginning in the freshman year.

But not all entering freshmen engineering students will have had strong preparation in high school mathematics. There is reason to hope that significant improvements can be made in our methods of taking care of those students. Williams College has been successful in taking students without trigonometry directly into the unified calculus, analytic geometry, and differential equations course and to develop the necessary analytic trigonometry as it is needed in the calculus. The universal freshman program envisioned by the MAA Committee on the Undergraduate Program will presuppose only one year of high school algebra and one year of geometry. A program in mathematics and physics was devised at Lafayette College for students enrolled in the preinduction program sponsored by the Ford Foundation. Most of these men entered college after two years of high

school. They had studied neither physics nor trigonometry and their mathematical background was primarily limited to one year of algebra and to one year of plane geometry. The two year program at Lafayette included the essential parts of trigonometry, analytic geometry, calculus, and differential equations. Experiments along these lines while not conclusive do at least suggest the possibility of bypassing some of the traditional prerequisites for the calculus with a resulting acceleration and expansion of the useful mathematics that can be included in the normal engineering curriculum. However, some serious questions have been raised in connection with these experimental programs. The major items of concern seem to be:

1. that the existence of the experimental programs, with the low level of mathematical pre-requisites for some of them, may result in a further weakening of the high school mathematics preparation of future engineers and scientists. It is taken as axiomatic that high school students will not learn as much mathematics in two years as they would in four. In the face of increasing demands for mathematical competence, the colleges and universities (so the argument goes) should, if anything, be upgrading their entrance requirements in mathematics for students in engineering and the physical sciences. And the University of Illinois, for one, seems to be moving in this direction.
2. that the experimental courses may attempt to survey so many topics that they will attempt to teach "a little about everything and not much about anything." This may be an exaggerated fear, but it nevertheless exists.
3. that "by far and away the largest portion of engineers get along on and *use* a fair amount of the elements of algebra, plane, solid, and analytic geometry, trigonometry in particular, plus the fundamental concepts of the calculus and copious use of handbooks and tables. Moreover, whatever the shortcomings of the traditional first year mathematics courses in engineering may be, they have at least made a serious attempt to meet the student where his knowledge left off and usually provide time for review and filling in gaps."

This Committee has not had the opportunity to debate the issues raised here. Accordingly, we make no recommendation either for or against any of the experimental programs now under discussion. We do, however, endorse experimentation as such. Moreover, we feel that the prospect for curriculum improvement is enhanced by a lively and serious debate of these issues.

We also wish to call attention to an experiment of a somewhat different nature, designed to stimulate gifted students to make more progress in mathematics at an early age. The Ford Foundation through its Fund for the Advancement of Education has recently sponsored a study called "The School and College Study of Admission with Advanced Standing." The Mathematics Committee of that Study proposed a program in mathematics for the more able students which would include a strong introduction to differential and integral calculus in the *twelfth grade.* And, in a similar vein, we wish to call attention to a recent talk by R. S. Burington on "Mathematics for Our Time," reported in the *Mathematics Teacher,* vol. XLVII, No. 5, pp. 295–298, May 1954.

What conclusions, then, has this Committee reached in answer to the question "What mathematics should be taught to engineers"? We wrote personal letters to about forty mathematicians, scientists, and engineers soliciting their comments and advice on the question of what mathematics should be taught to engineers, and how it could be taught most effectively.

From the replies received we deduced that:

a. There was a consensus of opinion that all engineers would benefit by studying mathematics through at least the elementary course in ordinary differential equations.

   On the question of specific course content we are not prepared to take a stand either for or against the program proposed by the MAA Committee, largely because it is still in the experimental stage and because of certain doubts stated above.

b. Statistics and probability deserve more attention than they now receive.

   It is not at all obvious how this is to be managed within the present time limitations. One possible solution to the problem has been suggested by the MAA Committee on undergraduate curriculum. This problem deserves further study.

c. It would be highly desirable to provide the opportunity for students to take further electives in mathematics; for example advanced calculus, complex variables, numerical analysis, matrix algebra, and so on.

Who should teach mathematics to engineers? There is, of course, the possibility of a dichotomy with some people answering "the engineering staff, in order to increase motivation" and with others answering "the mathematics staff because of their deeper insight into the logical structure of the subject." In his talk at Urbana, L. W. Cohen referred to mathematics as a language. In order to learn to use this language effectively engineers need teachers who know the language thoroughly and know how to use it. In this connection we quote from the interim report of the Committee on Evaluation of Engineering Education of June 15, 1954: "A minimum level of performance in mathematics should be established whether it be obtained in required mathematics or in engineering courses. However, few engineering courses are taught in a manner to make a significant contribution to the students' knowledge of basic mathematics, nor is time available for this purpose. The engineering sciences and subsequent professional subject matter should be developed by making effective use of such mathematical proficiency, and should be taught by staff members competent to do so."

We are in complete agreement that, in these days when some engineers need far more mathematics than the minimum now required, it is important that mathematics be taught by mathematicians who by their inspiration and enthusiasm can stimulate an interest in mathematics per se. Unfortunately, however, the impression exists that some engineering students are taught by mathematicians who have little or no appreciation for the interests and needs of the engineers. We believe that those mathematicians who are responsible for curriculum planning should consult with their engineering colleagues from time to time to try to determine the engineers' current and anticipated needs in mathematics. Then they should try to meet those needs by providing appropriate courses taught by competent, sympathetic teachers.

One experiment which has been tried, and which appears to be worth wider consideration, is for the mathematics department to invite a member of the engineering staff to teach one or more regular mathematics courses. This gives him a chance to become familiar with the structure and timing of the mathematics course, and also puts him in an excellent position to make criticisms and offer suggestions on the course from the point of view of an engineer. This might also be done on a reciprocal basis with a member of the mathematics staff teaching one of the engineering sciences in order to become familiar with the applications of mathematics in it. One member of our Committee has reported that he took part in such an experiment at the University of Illinois and found the experience valu-

able, particularly the discussions among these involved in the exchange teaching. This sort of exchange arrangement would be one way of helping a teacher to avoid getting into a rut. Other ways include: individual or group research projects, consulting on mathematics problems arising in industry or governmental laboratories, sabbatical leaves, and so on.

There are two aspects of motivation that bear further mention. On the one hand, mathematics should continually draw upon the physical and engineering sciences for illustrative problems. But, of equal or perhaps greater importance is the fact that motivation is tremendously enhanced if liberal use is made of mathematical techniques in physics and the engineering sciences, both in the first two years and in the later years. We quote again from the interim report previously cited (p. 11): "In the engineering sciences, full use should be made of the prerequisite mathematics, physics, and chemistry, recognizing that repetition is a normal pedagogical necessity, but that it can be most effective only when consciously and purposefully used. Perhaps nowhere else can the qualities of a scholarly engineering faculty be employed so effectively as in the presentation of these engineering sciences with an appropriate mathematical understanding."

How shall mathematics be taught to engineering students? These students are interested in mathematics as a tool. The majority of them are not content to study mathematics for its own sake. They usually can be induced to become interested in "why" a technique works, but only after they are convinced that: (a) it is a useful technique, and (b) they understand how to apply it. Teachers recognize this fact by using a large amount of problem material. In this connection, we should like to call attention to the collection of "Engineering Problems Illustrating Mathematics," prepared by a committee of the ASEE under the chairmanship of John W. Cell, and published by the McGraw-Hill Book Company in 1943. These problems are divided into categories illustrating the mathematics usually covered in college algebra, trigonometry, analytic geometry, and differential and integral calculus. It has been suggested that more material of this kind would be helpful. In particular, more examples where the emphasis is on the analysis of the problem and the methods for setting it up in mathematical form, would be desirable. A fund of such problems requiring statistical techniques would be particularly welcomed by some teachers. Our deliberations and the replies to our inquiries have indicated needs for:

a. More emphasis on numerical methods.
b. More emphasis on graphical methods.
c. More emphasis on fundamental concepts.
d. More emphasis on translation from physical problems to mathematical problems, and on the interpretation of the results of the solution of the mathematical problems in terms of the given physical problems.
e. More use of mathematics in junior and senior engineering courses.

Much has been published on the question of improvement of teaching methods. The Committee feels it is appropriate to list here, for convenient reference, the following books and articles which are related to the work of the Committee:

BOOKS AND ARTICLES RELEVANT TO THE WORK OF THE COMMITTEE

J. W. Cell, "Engineering Problems Illustrating Mathematics," McGraw-Hill (1943).

"Effective Teaching," McGraw-Hill (1950) (Fred C. Morris, Editor).

Report of the SubCommittee on Minimum Essentials in Mathematics for Engineering Instruction—California Committee for the Study of Education.

Report of the Committee on Adequacy and Standards of Engineering Education, *J. of Engineering Education*, vol. 42, No. 5 (1952), pp. 249–254.

Proceedings of the ASEE.

Vol. 39	1931–32	pp. 299–310
42	1934–35	149–152, 292–296
45	1937–38	122–131, 190–194, 548–558
46	1938–39	716–724
47	1939–40	394–401, 699–703
49	1941–42	57–66 , 346–352
50	1942–43	432–437
51	1943–44	664–668
52	1944–45	407–413
54	1946–47	330–335, 531–535, 536–539, 641–652
55	1947–48	175–180, 300–307, 308–312, 358–365, 366–373
58	1950–51	308–310
59	1951–52	170–172
60	1952–53	33–46 , 136–144, 472–475

Conclusion

One imagines that the question of "how to teach (anything)" most effectively confronts every conscientious teacher almost constantly. One also feels that the question of *motivation* on the part of the teacher is at least as important as it is for his students. If he feels that *what* he is teaching is interesting, important, esthetic, and useful—then his enthusiasm will almost certainly stimulate his students to *learn*. But no teacher can long maintain a fictitious enthusiasm for subject matter which, to him, is dull, trivial, non-esthetic, and largely useless. It is for this reason that the committee chose to include a consideration of *what* mathematics to teach as well as *how* to teach it. We do not propose any definite answers to either question. But we have pointed out some experiments which seem, to us, to be significant. In doing so, we hope not only to recognize and encourage those who are conducting these experiments, but also to stimulate others to devise their own or try some of the existing ones.

Recommendations

We recommend the following to the ASEE and MAA and their respective members involved in the teaching of mathematics to engineers:

1. Use all appropriate means to encourage better mathematics preparation in the high schools.
2. Teach "operational" rather than merely "appreciative" mathematics to engineers in the first two years of college.
3. Understand the engineers' needs and try to meet them, whatever the level of preparation.
4. Debate vigorously the issues involved in curriculum structure.
5. Make a serious attempt to introduce statistics and probability into the curriculum in the first two years.

Respectfully submitted:

R. S. Burington
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The New Position of Science*

By GILBERT E. DOAN

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For the past hundred years we have looked to the methods of science to guide us to verifiable truth about the world we live in and to free us from old-fashioned dependence on tradition. The gulf between science and faith seemed too wide to bridge. We had to choose, and without admitting it to our conscience, we chose science as the most trustworthy guide.

Education in general gradually shifted its weight during that century from the classics to science. History, philosophy, and literature developed scientific foundations. Today even these "humanities" are pursued by scientific methods. Our universities have increasingly copied the German institutions where research is the primary concern.

Leadership of Science

Has science justified this 100 years of our confidence? Is its leadership still strong? Let us see what the leading scientists themselves answer today. Lord Bertrand Russell, one of the leading scientists, and a philosopher as well, says:[1] "It is a curious fact that just when the man in the street has begun to believe thoroughly in science, the man in the laboratory has begun to lose his faith.

"When I was young, most physicists entertained not the slightest doubt that the laws of physics give us real information about the motions of bodies, and that the physical world does really consist of the sort of entities that appear in the physicists' equations—Nowadays matters are quite different; the revolutionary ideas of the philosophy of physics have come from the physicists themselves, and are the outcome of careful experiments. The new philosophy of physics is humble and stammering, where the old philosophy was proud and dictatorial."

Certainly this admission, after 100 years of our deepest trust, must force us to reconsider our faith in the methods of science and in the findings of science, where they extend beyond the strict confines of the physical world.

Dirac, the great mathematical physicist, puts the case even more strongly: "Nature's fundamental laws do not govern the world as it appears in our mental picture in any very direct way, but instead they control a sub-stratum of which we cannot form a mental picture without introducing irrelevancies."

Have we, one might ask, been pursuing a will-o'-the-wisp in our devotion to science? Certainly it would appear so if we thought the scientific method had general instead of merely specific validity in its own field.

The Validity of Science

But Prof. M. Polanyi, F.R.S.[2] at Manchester University, England, presents the general summation to the question of the validity of science:

"The 'suppositions' underlying our

* Reprinted from *Mechanical Engineering* for January, 1955, pp. 28–29, with permission of Copyright Owner.

[1] *The Scientific Outlook*, p. 88, Free Press, 1931.

[2] "Science, Faith and Society," Oxford University Press, London, England, 1946, pp. 1, 17.

belief in science are more extensive than is usually thought. These suppositions co-extend with the entire spiritual foundations of man and go to the very root of his existence. Just as there is no proof of a proposition in science which cannot conceivably turn out to be incomplete, so also there is no refutation of a proposition in science which cannot conceivably turn out to have been unfounded."

Instead of getting at least one foot down on the solid ground of reality through the discoveries of science, it is clear that both our feet are still firmly planted in mid-air. Aside from its utilitarian value, which is great, science too is still a matter of *faith in suppositions.* It is clear that the miracles of science such as human flight, television, and the curing of disease are the fruits of a system which is built on unproved assumptions—*a faith, a creed* like the one we confess in church, only the creed of science is implied, not confessed.

Not only are the laws of science based on suppositions as is clearly revealed in the foregoing, but the outstanding findings of science repeatedly violate its own basic articles of faith. Let us be specific: For centuries Newton's laws governing time and space were accepted as physical fact, basic and immutable. Then Einstein modified Newton's laws. Today, time and space are no longer absolute quantities, but varying and uncertain things.

Again, the law of the constancy of energy was changeless "fundamental fact." It too was one of the "ultimate truths" of science. We brought all our discoveries to this law to test them. Then the atom bomb exploded and proved that new energy could be created out of mass, ($E = mc^2$). Today this so-called fundamental fact of the constancy of energy admits of exceptions. These are not corollaries of science, they are its *basic articles of faith.*

Three-hundred years from today the "truths" of science will be yet more greatly changed. As Polanyi puts it, even the fundamental laws of science "carry within them the human assumptions which eventually lead to their decay." [3] We come closer to absolute truth with each scientific discovery but we never can say, "This will never change."

Alfred North Whitehead,[4] the mathematician and philosopher, carries us into the clear on the entire question, as usual:

"We supposed that everything of importance about physics was known. Yes, there were a few obscure spots, strange anomalies having to do with the phenomenon of radiation which physicists expected to be cleared by 1900. They were. But in so being, the whole science blew up, and the Newtonian physics, which had been supposed to be fixed as the Everlasting Seat, were gone. Oh, they were and still are useful as a way of looking at things, but regarded as a final description of reality, no longer valid. Certitude was gone."

Finally, Sir Winston Churchill [5] realizes this co-relative position of science and expressed it clearly at the M.I.T. Mid-Century Symposium. He said:

"No technical knowledge can outweigh knowledge of the humanities in the gaining of which philosophy and history walk hand in hand. Our inheritance of well-founded, slowly conceived codes of honor, morals and manners, the passionate convictions which so many hundreds of millions share together of the principles of freedom and justice, are far more precious to us than anything which scientific discoveries could bestow."

Thus leading scientists and statesmen have concluded that neither scientific methods nor scientific discoveries have freed man from reliance on faith. The scientists are quite frank in their admission. This disclosure challenges the

[3] "The Logic of Liberty," University of Chicago, Chicago, Ill., 1951.

[4] "Dialogues of Alfred North Whitehead," by Lucien Price, 1954, p. 7. Little, Brown & Co., Boston, Mass.

[5] "Mid-Century," J. E. Burchard, editor, M.I.T. Press, 1950.

position of American intellectuals in almost all fields. We had fondly hoped that our intellects would make us self-sufficient, that the worship of Deity would become unnecessary. But science can't do this. Let us see how this admission must change our teaching of science.

Democracy Also Based on Faith

In western civilization this admission actually revives our trust in the democratic way of life. Like science democracy, too, is based on faith, on belief in the objective existence of truth and justice.[6] The belief in objective justice, and man's obligation to practice it, are matters of faith, not proof. You cannot prove that man ought to be just; you cannot prove that we ought not permit the forcible repatriation of Korean prisoners.

These are parts of our basic faith. Thus the "miracles of science" achieved in the laboratory such as flight, radio, and disease control are paralleled by the "miracles of democracy" achieved in society, such as freedom, human decency, and prosperity. *Both science and democracy are the fruits of faith.* Knowledge and proof trail along afterward. Instead of a flimsy delusion, faith turns out to be the keystone of our western system, both in science and in democracy. President Eisenhower, in his inaugural address, endorsed this position by his personal example. We may not *prefer* a world founded on faith, but if that is the reality we ought to face it squarely as this country has in the past, with very great profit. Certainly it is better than a world founded on *fear* as is the Communist world. After decades of doubting democracy and envying the rigid logic of totalitarianisms we suddenly discover that our own system makes much better sense, that science, democracy, and religion under the Supreme Being are compatible elements of the western tradition. This is the meaning of the motto on our coins: "In God We Trust."

[6] *Fortune Magazine*, February, 1951.

What must be done as a result of the newly revealed position of science? Must we return to traditional thinking? Must science recede from liberal education, and will dogmatic thinking then return to its entrenched position? Must research and experiment cease? Certainly not! Science has great value as one of several approaches to truth. As a mature nation with heavy world responsibilities our colleges and universities must carry both programs—the transmission of the western tradition based on faith, and the advancement of knowledge through research. There is work for both the humanities and science.

The American Society for Engineering Education has sensed the need for humanities in the engineering curriculum, perhaps without fully realizing why they are essential in transmitting democracy. The Society recommended a minimum of twenty per cent of humanities in every engineering curriculum, and most engineering colleges have put this recommendation into effect.

But the fiduciary nature of science must be frankly admitted to students, for its foundation-in-faith is its basic characteristic. *Only when a student realizes that science is based on faith can he confidently accept the tenets of democracy and religion which are likewise based on faith.* To teach men and women that science is verified truth, which therefore renders faith superfluous, as we have been doing, is not only to teach a falsehood; it teaches a falsehood which makes minds unwilling to accept the tested tenets of democracy. Students in America are confused on the basic issues of life. No wonder Lenin, Stalin, Molotov, and Vishinsky have laughed at democracy for its confused thinking and contradictory teaching!

Faith and Free Society

A free society, such as ours, is *not* an open society where everyone can do as he pleases. It is one strictly dedicated to transcendent ideals. If we lose faith in

objective justice, charity and personal integrity, as the Marxists have done, then both our material prosperity and our freedom (free enterprise, academic freedom, religious freedom, and political freedom) must disappear as they did in Germany and Russia. These beliefs have survived in America more because of their *practice* in industry, in the home, and on the farm, and because of the influence of the church rather than as a result of intellectual leadership or college teaching. We could use a little more intellectual leadership at this point! The college also should *practice* these beliefs. For instance, the personal integrity of a student ought to be intensively developed there, as it is at the leading women's colleges under the honor system to-day.

America is still wedded to faith. This union, joined in Washington's and Jefferson's day, is still unbroken. It has born the marvelous fruit anticipated. We ought to acknowledge our faith with pride; teach it openly and *make no exception for science.*

There is some evidence that the colleges are beginning to integrate science with democracy and religion, the other major areas of western faith. If this integration is achieved, then the university again can become the backbone of our civilization. Science will contribute richly to truth without in the least discrediting the other major areas of faith. For us as individuals the need to choose between science and faith as a guide in our personal lives has disappeared. *Both are faith.* Once more men are free to believe! On this basis the whole of western civilization (and the whole personality of the individual, once he has repented of his idolatry of science) can again go forward.

In the News

The **National Science Foundation** will consider applications for the support of travel to assist a limited number of American engineers to attend the 6th Plenary Meeting of the International Association for Hydraulic Research, to be held from August 29 to September 2, 1955, at Delft, Netherlands. Application forms may be obtained by writing to the Division of Mathematical, Physical and Engineering Sciences, National Science Foundation, Washington 25, D. C. Applications must be received by May 1, 1955, in order to be considered.

Publication is announced of "Professional Engineering Registration Laws," a compendium of registration laws for professional engineers in the 48 states, Alaska, Hawaii, Puerto Rico, and the District of Columbia. The 614-page book has been compiled by Alfred L. McCawley, attorney and former Missouri State Senator. The compedium is the culmination of an extensive research project undertaken by Mr. McCawley under the sponsorship of the **National Society of Professional Engineers.**

Published at $8.75, the book presents, state by state, the exact legal requirements that must be met for professional practice. It is a reference volume designed for the professional engineer or the engineer-in-training who plans to practice on a permanent or part time basis in another state or territory.

The compendium covers in detail such elements of the state laws as temporary permits, fees and bonds, the filing of maps, certificate applications, education requirements, examinations, and public works projects. The laws are cited for reciprocity, registration renewals, corporate and partnership practice, revocation of registration, and violations and penalties.

The book may be ordered from the Trustee Publication Fund, Jefferson City, Missouri.

Engineering Education Behind the Iron Curtain*

By EDWARD KEONJIAN

Electronics Laboratory, General Electric Company, Syracuse, New York

Fundamental difference between the educational system of the free society and the totalitarian state is that in the free society education is built around the individual, while in the totalitarian state it is the state itself, in behalf of which the interests of the individual must unconditionally be sacrificed. Consequently, a liberal arts education, which is so popular in the Western World and which provides only a broad cultural background, is unknown in the Soviet Russia, where the education exclusively serves the specific tasks in the National economy and world communism.

An exhaustive evidence of this philosophy in regard to Soviet universities can be found in the "Soviet Great Encyclopedia," V. 9, pp. 512, 1951, which states that the purpose of Soviet universities is ". . . to prepare highly qualified politically trained engineering personnel . . . devoted to the course of Lenin-Stalin, capable of . . . merging, in a Bolshevik way, scientific theory with the practical work of building a Communist society."

The exclusive emphasis on the state and its needs can be found almost in every text book including highly specialized text books in every field of science and technology. For example, even pure technical books, as "Testing of Radio Materials and Parts" (Kazarinovsky, Moscow-Leningrad, 1953) has this to say: "Creation of the technical base of the Communist society, introduces new problems to the people of our country. The science and technology must serve for realization of these problems."

It will be wrong to assume, however, that this philosophy is carried out in the Soviet higher educational systems only. From the day that the child enters the elementary school, he is trained to learn what is good for the State and only for the State. I remember very well one of the textbooks for elementary schools, from which Russian children of eight had to learn to read and to know about the rest of the world. Here is how the book is described by the former U. S. Ambassador to Moscow, W. C. Bullitt.

". . . above the title "America" was a drawing which depicted hideous men and women wearing jewels and elaborate evening clothes, dancing to the music of a jazz band while in a cellar below the dance floor emaciated children worked at factory machines. The text read: "America is a country where children of workmen and farmers are forbidden to learn to read and write. They are given nothing to eat but bread. At the age of six, they are put into a cellar to work at factory machines, while the rich dance over their heads."

"Amused at first at the absurdity, I soon realized that this was no laughing matter. The first impression that Stalin's little slaves can get of my country would come from that picture and that lie. Thereafter, the children would be inclined to think of the United States with hatred and contempt."

When the ambassador showed this book to one of the Soviet Ministers and asked how they can teach the children such ridiculous untruths, he received a reply from the Soviet Minister which stated:

* Presented at the ninth annual meeting of the Upper New York State Section of ASEE, on October 22, 1954, in Ithaca, New York.

"... we shall teach the children exactly what is good for the Soviet Union to have them believe."

The same techniques of deliberate distortions of the truth can also be found in the textbooks of the Soviet high schools.

Following the rule that "we shall teach them what is good for the Soviet Union to have them believe," the American history in Soviet textbooks is just history of lynching of negroes, history of American gangsters, of Sacco and Vanzetti (I lived next to the plant named after Sacco and Vanzetti), of Chicago slums, of economic depressions, strikes and so on. On the other hand, such basic subjects as mathematics, physics, chemistry, geography and others, are taught thoroughly and high school pupils are well prepared for entering into universities.*

Dut to the this fact, the Soviet universities do not have to spend part of their program on the fundamentals, which leave more time to go deeper into specialized subjects, and, of course, also more time for indoctrination courses, such as the fundamentals of Marxism, Leninism and Stalinism. Thus, from the very first days in school, the student is educated as a specialist and his entire curriculum is made up to meet the need of National Economy and World Communism.

The methods of teaching in the universities that have been developed through many years in old Russia, have been extensively and drastically changed several times since the Communists took over, and textbooks, even highly specialized, have been revised several times in accordance with the frequent changes in political situation in Soviet Russia and numerous purges.

How are universities and engineering schools organized in Soviet Russia today?

There are two types of universities in Soviet Russia:

(1) Regular universities for pure theoretical specialities such as physics, astronomy, mathematics, etc. as well as for preparation of high school teachers. It requires five years to graduate from there.

(2) Institutes which have the same university standards, but are more specialized.

In Soviet Russia, the majority of schools are of the second type, i.e. highly specialized. For example, according to official information, among 887 various Soviet schools of university and college standards (in 1953), there were only 32 universities with approximately 87 thousand students. The rest of these schools (i.e. 96.4%) were comprised of 167 technical institutes with approximately 240 thousand students, 90 agriculture institutes, 72 medical institutes, institutes of economics, physical culture, etc.

The technical institutes are of two following types:

(1) Polytechnical institutes, which generally are located in large cities and have approximately one dozen faculties.

(2) Specialized institutes such as institutes of Electrical Engineering, Mechanical Engineering, Chemical Engineering, etc., each with 5 or 6 faculties or departments.

As you can see, the institutes as well as the faculties in these institutes are more specialized than here. It is interesting to note that the people in Soviet Russia believe that American universities are specialized at much higher degree than the Soviet institutes.

In spite of this narrow specialization, the fundamental subjects, such as advanced mathematics, physics, electrical field theory and others, are compulsory for most of the specialized institutes, and during the first two years, the students

* Recently, the Soviet leaders emphasize that most of the students finishing the secondary schools will not take further full-time schooling but will go directly into the labor force. Therefore, in the Communist view, the main responsibility of Soviet schools is to train boys and girls "to love work" and to observe academic discipline that can be translated into "labor discipline" as soon as the students take their first jobs.

have to study these subjects very thoroughly. The special subjects start usually toward the end of the 3rd year of the school and continue in the 4th and 5th years. For example, as a student in electronics specialization, I had to study such subjects as communications, vacuum tubes, high frequency measurements in second and particularly in the third year of my school. During the 4th and 5th years, I had to take such specialized courses as radio antennas, microwaves, transmitters, receivers, etc.

No Elective Courses or Humanitarian Subjects

It should also be noted that the Soviet institutes do not have any elective courses or any humanitarian subjects whatever. Instead, the students in every university and institute are obligated to take certain political courses every year of school, even if one stays in the school after his graduation to complete his doctorate.

What are these political subjects?

1) Fundamentals of Marxism and Leninism
2) Political economics and economical politics
3) Dialectical materialism
4) History of the Communist Party

These political subjects are introduced into the curriculums of every technical school in accordance with the rule which was quoted previously that the purpose of Soviet universities is ". . . to prepare highly qualified, politically trained engineers . . . capable of merging, in a Bolshevik way, scientific theory with the practical work of building a Communist Society."

Officially, the political subjects comprise 8% of curriculum of the engineering schools, while 25% of the time is devoted to the basic courses and 65% to special courses. Actually, the political subjects take at least 10% of student's time and are always regarded to be much more important than any other subject. The brain washing is a very important process in every school of Soviet Russia, and the Soviet Government never fails to prove it by expelling students immediately from the schools as soon as they fail in one of these political subjects.

Everybody in Soviet Russia takes this for granted and the only trouble is that the professors who teach political subjects are usually expelled more often from the universities than the students. This is due to the fact that professors of political science are members of the Communist Party. For them occasional misinterpretations of the fundamentals of Marxism, or wrong examples which they might use to illustrate certain laws of Marxism, are equivalent to state crime.

The curriculums of the technical institutes usually require 10 semesters, of which 16 weeks should be spent on practical work in industry and last semester on the preparation of diploma project, which is equivalent to a Master's thesis in this country with the exception that in Soviet Russia, the diploma has to be defended publicly by the student.

After a student is out of school, he automatically receives his job assignment and must go to any place where the government will send him at salary which the same government will find appropriate to pay him. Officially, one has this compulsory work for the first 3 years, only, but actually after the 3 years are over, the management automatically extends the term for another 3 or 5 years. In some cases, when a student displays good and unusual ability in the teaching profession or in research, the school will keep him after graduation for another 3 years for graduate study and research work. At the end of this program, he has to make another thesis for his "candidate" degree which is equivalent to Ph.D. in this country. In order to receive the Doctor of Science degree, the holder of a candidate degree has to spend a few more years for extensive study of advanced courses and has to accumulate enough experience in research, before he can be entitled to public defense of his last

doctor's thesis, which should be an original work of significant value.

Doctor's degree can be awarded also to some outstanding engineers and scientists without examinations, and without thesis, providing that they have at least 20 years practical experience in research and engineering and have contributed a great deal to the science or to technology of the country.

Student Organizations

The Soviet schools do not have any special student clubs or fraternities since the Soviet Government never trusts any organizations which are not organized by the state and which are not supervised by the secret police. The same is true about students' sports organizations. Athletes may join the only two existing clubs: Dynamo or Sportac, which are operated directly under the supervision of the ministerium of secret police.

If someone displays outstanding ability in athletics and desires to become a professional sportsman, he will be admitted into a special institution of Physical Culture. One such institution named Lesgaft was located in Leningrad. In this institution, students spent 4 years of intense physical training under permanent medical care, to make them outstanding professionals. After graduation from these schools, the government sends these professionals as "amateurs" into various countries to compete with Western amateurs and to beat them, so that the Soviets can get the maximum propaganda out of this. The government invests millions of dollars in this, but it pays off as you can see from the recent results of the Olympic games in Finland, Sweden and England.

Who Are the Professors in the Technical Schools?

A great number of them consist of specialists who managed to be transferred from industry into the schools, though such a transfer reduces the salary of the specialists.

An explanation for this lies in the fact that when a specialist works too long in the industry of which 9 out of 10 are classified projects, he knows that if he fails, he can very easily be accused of being a saboteur and be sent to a concentration camp. Therefore, many specialists and scientists prefer to switch to university work before they can be banished. The Soviet universities usually benefit greatly from such a situation because, in this way, they are able to add many good specialists to their staff.

There are no religious studies in the Soviet universities. No programs of foreign universities can be found in the libraries of the schools, as well as no foreign students can be found in Soviet universities, from the Western countries.

There is no association of university professors which is concerned with the problems of academic freedom, or international conventions, conferences, exchange of information or teaching methods with universities, etc., in the Western countries.

In each subject, the professor must introduce political fidelity and has to match his subjects somehow with the fundamental principles of dialectical materialism. If he fails—he cannot stay in the school.

Conclusion

1) The final aim of the Soviet Government is the conquest of the world and, consequently, all the efforts of that country, all the resources and manpower, are directed toward that basic goal.

2) One of the essential means to reach this goal is a highly developed industry which is able to produce enough military equipment.

3) To run this industry, the Soviets need a large number of good engineers and therefore spend enormous sums of money for the education of these engineers. Today, the Soviets prepare approximately 30,000 engineers and 110,000

technicians every year, who almost entirely are absorbed by the military industry.*

4) The engineers in Soviet Russia cannot be only professionals, but they must also be politically educated. Therefore, in all technical schools, political subjects are compulsory and no engineers can graduate from any school without being completely familiar with the Communist's interpretation of politics and world affairs.

5) Tremendous programs of expansion of military industries and the preparation of thousands of engineers are not indications of any prosperity in the Soviet State, since it is usually carried out at the expense of the civilian economy, lowering the producion of common goods and the living standards of the people.

6) There is, however, one more important point. The Soviet system has completely destroyed the most precious of man's birthright, which is his personal freedom, and for which there is no substitute.

This is a fact which some people prefer to ignore when they enthusiastically praise the "wonderful achievements" of the modern slave state called the Union of the Soviet Socialistic Republics, or USSR.

* According to the latest information, the number of engineers graduating from the schools in Soviet Russia in this year reached 50,000; however, this figure could be slightly exaggerated by the Soviet statistics for propaganda purposes.

College Notes

The **University of Michigan** announces a two week intensive course on Nuclear Reactors and Radiations in Industry to be given in Ann Arbor, August 15 to 26, 1955. The course is sponsored by the Nuclear Engineering Committee of the College of Engineering, and will be conducted by members of the Engineering College staff, assisted by guest lecturers. Staff members participating include Professors L. E. Brownell, H. J. Gomberg, W. Kerr, H. A. Ohlgren, and J. R. Sellars.

Lectures covering such topics as elementary nuclear theory, measurements of nuclear radiations, interaction of radiation and matter, and nuclear reactors and fuels will be coordinated with laboratory demonstrations, tours of University radiation facilities, and examples of industrial applications. Guest lecturers from industry will present current progress and thinking in the nuclear field. The one megawatt University of Michigan research reactor, which will be under construction during the course, will be inspected and discussed. Demonstrations using a multikilocurie gamma radiation source will be conducted. The course is intended for the engineer without previous experience in nuclear technology who wishes to acquire a knowledge of representative problems and techniques in this rapidly developing field.

Tuition will be $200. The fee includes a complete set of printed course notes.

For further details or for information on application, write Professor William Kerr, Department of Electrical Engineering, University of Michigan, Ann Arbor. The deadline for registration is June 1, 1955.

What Is Industry's Responsibility in the Training and Development of Engineers?*

(From the Viewpoint of Industry)

By FRANK J. LOCKHART

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Why is a company in business? What is its primary objective? To render a profit for the owners? To provide a commodity for its customers? Such questions have been debated over and over, usually to no definite conclusions. It appears to me as if we can get a better understanding by recalling the fable of the six blind men who were asked to describe an elephant after touching it. The first blind man approached the elephant, touched its ear, and said "Why, an elephant is like a big leaf." The second touched the elephant's trunk and said "An elephant is a big snake." The third touched the elephant's tusk and decided it was a spear. The fourth touched the elephant's side and said "The elephant is a wall." The fifth touched the leg and said "The elephant is a post." The sixth blind man touched the tail and said "The elephant is a twig." All of these men were right—in a very limited extent. But people of vision are able to see these individual parts in proper perspective and determine what an elephant does look like.

So it is with the primary objective of a company, or industry. From the limited viewpoint of the owners, the primary objective is to make a profit. From the limited viewpoint of the customers, the primary objective is for the company to provide a commodity. From the limited viewpoint of the vendors, the objective looks different. And likewise, from the viewpoint of the employees—as well as from the viewpoint of the community neighbors. Certainly the viewpoint of the competition is different from any of these above. Now we realize that each of these views is correct—in a limited extent. With broader vision we can see that the primary objective is six-sided, with each face different in appearance from the other five.

Such an interpretation of the objective of a company or industry is held by more and more industrial leaders. It is a broader interpretation than any held previously, and is the long-range viewpoint accepted by companies planning for the future.

Now as to the prime function of a company or industry. Using the word "manufacturing" in a broad sense, we can say that all companies are manufacturing something, in that they first take raw materials, and second perform some processing or manufacturing operation on them, to arrive at a finished product or commodity. A company or industry does exactly the same "manufacturing" operation with respect to its employees; first it hires people with certain qualifications (or specifications), and second it trains or develops these people, again to arrive at a finished product, mature, capable specialists or administrators.

* Presented at a meeting of the Educational Council for the Engineering Societies in Los Angeles, October 27, 1954.

Historically, companies have kept balance sheets on the material things. Today, companies planning for the future also keep balance sheets on manpower resources and requirements. Why? Because it is realized that the value or worth of a company *is* the quality of its people. Please note that I did *not* say "*depends on* the quality of its people," I said "*is* the quality of its people." In the final analysis, people do the work; people do the manufacturing. Machines can only help the people. If you want to see the machinery fall apart and the raw materials wasted, take the human element away.

I'm certain there are a number of skeptics who consider the foregoing as a collection of nice ideas—"but after all, isn't the success of business still measured by profit?" That comment is true based on a short term operation—because the other items involved in the objectives and functions can not be put down in cold, hard figures on a balance sheet. They are intangibles on a short term basis. My point is that modern industry recognizes the importance of these intangibles even on a short term basis, although they do not appear on the financial sheet.

Most engineering educators recognize the similar situation involved in the giving of grades to students at the end of the semester. You may, by rules of your accounting system, be forced to give a *C* to a student you know is superior to another student who receives an *A*. In such cases you will give a higher recommendation about the *C* man, and thereby try to take the intangibles into consideration.

The above objectives and functions of industry are the basic principles of what many people call "scientific management." You will recall that the engineers are rightfully credited with giving first recognition and impetus to scientific management, which is now recognized as *not* the direction of things, but as the development of people.

General Area of Training

We consider engineering education, training, and development as a joint responsibility of universities and industry. For convenience let us consider the subject in terms of the following areas:

(1) Basic and applied sciences;
(2) The "art" of engineering;
(3) Professional ethics and behavior;
(4) Personal characteristics;
(5) Human relations.

No one of these areas is the exclusive domain of the universities or of industry. Universities and industry both must participate to some extent in all of them.

Realizing that engineering graduates are the end product of the university and the raw material for industry, I feel compelled to discuss the university's responsibility in the training of engineers before discussing industry's responsibility.

The University's Responsibility

In the first area, basic and applied sciences, the university has rightfully assumed the major responsibility and is doing an excellent job.

In the second area, the "art" of engineering, the university has played only a minor role, leaving this to industry. This is understandable because of the short time available for university training and the great number of entirely different industries which employ engineers. What is practical for one industry can not be used by another. Furthermore, most students do not know what industry they will enter, so would be unable to specialize so early.

The third area, professional ethics and behavior, is one where the university has not participated as much as it should. It is felt that the university can contribute in this area by introducing senior students to the Code of Ethics, and by discussing various problems such as labor unions, professional registration, and various professional societies.

The fourth area, that of personal char-

acteristics, is one shared perhaps equally by the university and industry. The university has not contributed its share towards training in this area. I would like to be more specific in three ways:

(a) In the area of physical appearance and mental attitude, attention is called to the many articles and pamphlets dealing with the personal interview, with the various kinds of jobs inside the different engineering fields, and with aptitude testing. Such topics would be very helpful for discussion with senior students.

(b) I am convinced that conventional engineering education smothers originality, imagination, and initiative. And these are the very qualities which industry and our country need. Too often, young engineers are parasites of the experts—either those people who write the books or the professors. For example, many schools, or books, or professors make one such serious mistake in introducing students to the so-called "scientific method." After the problem has been defined, students are instructed to make a literature search immediately, to see how others have handled the same or a similar problem. That in itself puts blinders on the students' eyes—again they are parasites of experts.

(c) Not enough attention is given at the university to perspective and to a sense of proportion. This criticism applies to each of the time-honored engineering working habits of accuracy, speed, and neatness. Too much accuracy is silly, not enough accuracy is tragic; too much speed is waste energy, not enough speed is dilatory; too much neatness is pompous; not enough neatness is sloppy. Too much or too little of any of these factors is expensive and wrong. University training can place more emphasis on the proper sense of proportion in working habits as well as on the proper perspective in maximizing important things and minimizing those that are trivial.

The fifth area, that of human relations, is one well-known to engineering schools today. Well-known, if for no other reason, because of the wide spread *fad* that engineering students need to take more courses in the humanities. There is no doubt that industry finds the engineering graduates deficient in communications —both oral and written. The average engineering graduates are lacking in understanding the universal need for salesmanship. I personally believe the engineering graduates are deficient in understanding of the qualities of leadership and the understanding of good citizenship. Some, but certainly not all of these deficiencies can be corrected by the engineering schools. Most of these deficiencies may be placed directly upon the liberal arts schools, or the arts and sciences schools, or whatever you call them —and especially upon the present courses in humanities taken by engineering students. The primary error? Definitely not the number of courses, but the quality of the present courses and the instructors. It appears to me that the engineering faculty should resist diluting the curriculum with more of the same type humanity courses, and should insist on upgrading or revising existing ones.

Industry's Responsibility

In the first area, basic and applied sciences, industry has done little, leaving this area almost exclusively to the university.

With respect to the "art" of engineering or practical application (the second area), it has been pointed out that the university can not assume responsibility for training. This is industry's responsibility. Companies of appreciable size recognize and accept this obligation. It has been pointed out many times that in the structural field the smaller engineering companies cannot afford to train young engineers. From direct personal experience, I know that the small engineering companies *can* afford to train engineering graduates in the fields of chemical, electrical, industrial, mechanical, and petroleum engineering. It is done every day. I cannot speak with authority about

the fields of civil and structural engineering; but in view of the overwhelming evidence in all other branches of engineering, I am compelled to ask the question: "Is structural engineering so entirely different from all other engineering?" I cannot believe that. If smaller companies can *not* afford to hire and train engineering graduates in structural work, then could it be the fault of the university training in this field?

The third area, professional ethics and behavior, is one which must be taught by the university and developed by the efforts of the engineers themselves. Industry is certainly receptive to such aims and encourages them. But I personally believe that industry's responsibility in this area is to provide the proper climate for individual growth.

The fourth area of training, that of personal characteristics, is one in which industry has changed remarkably during the last twenty years. The change has been from a "sink or swim" attitude toward the young engineers to that of constant guidance and counseling. This change in attitude may be attributed to "scientific management." Such activities are being worked on constantly and training in this area will continue to improve.

Human relations, the fifth area of this discussion, includes communications, salesmanship, leadership, and citizenship. Industry again has accepted its responsibility for training in these areas, and will expand its efforts. Companies are training their people and encouraging them to seek outside training in oral and written communications, in the art of gentle persuasion, in salesmanship and leadership. Companies encourage (and in many cases insist) their people take active part in community affairs. Participation in church affairs, governmental work, various charities and community projects, jury duty, and many others are some examples of this.

Now that we have talked about industry's *responsibility* in training and development of engineers, just exactly how can industry do these things?

How Industry Can Help the University

Industry can aid the university in training the engineering students in a number of ways, such as:

(1) Informing the university of industrial trends which suggest additional or improved engineering training;
(2) Rendering financial aid to the university and/or students to meet rising costs;
(3) Offering "on-the-job" training to educators and students by summer work, part time employment or consulting, cooperative educational programs, and "exchange" plans;
(4) Offering the services of professional engineers and managers, when requested by the university, to give lectures and teach special courses;
(5) Offering instructional aids such as technical bulletins, exhibits, and models.

Most companies participate in one or more of the above activities, and all companies desire to aid the university in all possible ways. I personally think that the university does not ask industry for nearly enough of such help.

How Industry Can Train Engineers

After graduating from the university, young engineers are ready to start their industrial training. Industry aids in this training in a variety of ways, some of which are:

(1) Encouraging further education, such as graduate work, special courses at the university, night-school classes, and short term courses of various organizations;
(2) Encouraging high professional standards by recognizing professional registration and technical society activities;
(3) Utilizing formal training programs of the proper quality.

However, it appears to me that the most important principles of training and developing engineers in industry are:

(4) Training should be done mainly by the company in terms of its own policy, practice, and need, rather than by an outside agency;
(5) Training should be a direct responsibility of the line supervisor as an emphasized part of his job duties—that is "on-the-job" training.

In summary, the training and development of engineers is a joint responsibility of the university and industry. The university does the major share of training during the school years, aided to a minor extent by industry. After the young engineer graduates, industry does the major share of training, aided to a minor extent by the university. Training is now recognized as being an everyday part of every industrial supervisor's job. What is industry's responsibility? We have discussed the broad way in which industry views its objective, and how industry realizes that its true worth is the quality of its people. Industry must improve the quality of its people, its engineering specialists and engineering administrators, in order to survive.

College Notes

A Special Summer Program on "Industrial Applications of Heat Transfer to Electronics" will be offered at the **Massachusetts Institute of Technology** during the two-week period of the 1955 Summer Session from June 14 through June 24. Professor Ernest H. Huntress, director of the M.I.T. Summer Session, says that it is primarily designed for "engineers in research and development fields of electronics, electrical engineering, and mechanical engineering, who feel the need for better facility with the basic concepts, design methods, and applications of heat transfer."

The Summer Laboratory Course in Techniques and Applications of the Electron Microscope will be given again this summer from June 13 to June 25, 1955, by the **Cornell University** Laboratory of Electron Microscopy in the Department of Engineering Physics. The course, under the direction of Professor Benjamin M. Siegel, will have Professors Cecil E. Hall of M.I.T., Cambridge, Mass., and Robley C. Williams of the University of California, Berkeley, Calif., as guest lecturers this year.

The course is designed to give members an intensive survey of basic theory and interpretation of results. The registration is limited to a small group so that ample facilities are available for each one to pursue laboratory work in his special field at an introductory or advanced level depending on his previous experience. Further inquiries should be addressed to Professor Benjamin M. Siegel, Department of Engineering Physics, Rockefeller Hall, Cornell University, Ithaca, New York.

The **University of Kansas City** and **Cornegie Institute of Technology** will cooperate in a five year educational program leading to both liberal arts and engineering or science degrees. The program will go into effect September 1955.

In the plan, students will take three years of liberal arts with a major in science at the University of Kansas City then transfer to Carnegie Tech for two years of engineering or science. At the end of five years, they will receive bachelor of arts degrees from Kansas City and bachelor of science degrees from Carnegie.

Personality Factors in the Learning Process*

By W. R. LEPAGE

Professor of Electrical Engineering, Syracuse University

In spite of some rumblings on the horizon, college teaching still predominantly follows the traditional pattern whereby it is assumed that knowledge of the subject and ability to lecture clearly is all that is required of a teacher. We tend to assume that the student will receive and retain subject matter that is poured into him. Of course, this statement oversimplifies and exaggerates; nearly every teacher sooner or later comes to an empirical realization of the importance of certain conditions which must be met within the student if he is to learn. For example, we instinctively tend to realize he must have a goal (that he must want to know the subject), that he must be motivated so that he will listen attentively and study, and that he needs active participation in problem solving.

Following this intuitive approach, we teachers tend to acquire techniques in agreement with principles which have been established by specialists in education. We try to make our lectures interesting, we try to develop exercise problems that will excite their interest, we look for well written text books, and the like. Nevertheless, I think most of you will agree that many times these devices are disappointingly ineffective. Very often capable students do not respond, and almost always the response is less than desired. To illustrate, let me list a few examples from my own observations.

A well-prepared lecture, skillfully organized, may not get across to certain students;

Many students miss questions on examinations which we know they are equipped to answer;

Certain students always get about the same low grade, no matter how easy an examination may be;

Special concessions to students with hard-luck stories usually serve only to increase their demands for special treatment;

Some students may not avail themselves of faculty offers of help.

It is natural to ask ourselves why students only partially respond to our efforts to help them learn, and sometimes do not respond at all. We are perhaps prone to pass it off by saying some students are stupid, or lazy, and to assume we, as teachers, have done all we possibly can do to be of help. However, I believe problems of this sort are important enough to warrant critical study. Unresponsive and uncooperative students are important. Although they may be in a minority, they take up a disproportionate amount of teacher time, and they disorganize and retard the class. Also, unresponsiveness and uncooperativeness is not confined to poor students. I once knew a student who was practically incapable of turning in a laboratory report. He flunked one course because he didn't turn in any reports at all; but his performance in recitation courses showed that he had better than average technical ability.

My awareness of the importance of these phenomena has been growing over the past five years, starting from a rather accidental introduction to some of the modern theories of educational psychol-

* Presented at the Central New York ASEE Meeting at Cornell Univ., Oct. 22, 1954.

ogy. From formal and informal study † I acquired a viewpoint which seems to me to go far toward offering a deeper understanding of student behavior. I would like to share this viewpoint with you. In doing so I emphasize that a person studying in this field tends to develop his own private set of ideas; and therefore I will present my digest of what I have learned from others. I do not present myself as a psychologist, but as an engineer interested in problems of education. My discussion will of necessity be presented in the language of the layman.

We begin by noting that in teaching we are essentially interested in changing a person's behavior in a predictable way. Accordingly, we temporarily digress into the general subject of human behavior in order to enunciate a central postulate upon which my thesis will be based. This postulate states that *the response of a person to a stimulus is determined by how that stimulus is perceived by that person.*

This idea seems simple and logical enough. In fact, I would expect that most of you would say it is certainly true. However, this rather simple hypothesis has subtle meanings which have seemingly escaped conscious acknowledgment up until quite recently. It is these meanings which will be partially explored in the remainder of this paper.

Importance of Perception on Behavior

As an extreme sample of the importance of perception on behavior, suppose two persons are thrown into the water. One is a swimmer, and the other is not. Both receive the same stimulus; but their behaviors will be widely different. The swimmer perceives a familiar situation, and swims. His response is organized. The non-swimmer perceives the stimulus as a threat to his well being, and his response is disorganized.

† Particularly with Drs. K. M. Peterson and A. W. Coombs, both formerly of the School of Education, Syracuse University.

Another example comes to mind, which comes a bit closer to the teaching situation. In his book "A Smattering of Ignorance" Oscar Levant tells an anecdote about about a French-horn player in an orchestra conducted by Toscanini. The horn player had done a difficult passage flawlessly many times. Finally, one day Toscanini complimented him on his fine playing, mentioning how difficult the passage was. The next time the orchestra played the piece the horn player stumbled through it—with dire consequences afterward, as you may imagine. His behavior had changed. Why? In terms of the ideas of this paper, his response to his cue had changed because his perception had changed. Originally he had not perceived the passage as being particularly difficult; it was well within his capabilities, he thought, and he responded accordingly. He played it well. After being complimented he perceived the passage as difficult; in fact, from his stumbling performance, we may say that he perceived it as being too difficult for him. He was like the non-swimmer faced with the need to do what he perceived himself as unable to do. Therefore, like the non-swimmer, his response was disorganized.

We see that these two examples have a similarity, but they also have a difference, and this difference is significant. When the non-swimmer perceives that he cannot swim he is correct—in truth he cannot swim. In the case of the horn player, at the time of the disastrous performance his perception is inaccurate. He can play the passage—he had done it many times—but this fact means nothing to him at the moment. As far as he is concerned, at that time, it is too difficult for him.

Here we have an idea with broad implications. As was said before, response is dictated by perception of the stimulus. But now we have the important addition that *the perception may be grossly inaccurate.* This is why a person's behavior may seem strange, ir-

rational, or even bizarre to an observer. The observer does not know the perceptions of the behaver. When the observer can know the perception of the behaver, the behavior seems rational. An observer of the non-swimmer, if he knew he was a non-swimmer, would not be surprised at the disorganized response. However, in the other example we can speculate that Toscanini's perception of the situation was unchanged, and therefore that he probably did not understand the horn player's behavior.

To recapitulate, the behaver responds to the stimulus in accordance with how he perceives the stimulus, and this perception may be in error. I restate this because I want to phrase it in another way, as follows: *The behavior of a person always makes sense when viewed in the light of the way the situation seems to him.* Thus, in teaching situations, if a teacher can acquire a feeling of how the situation appears to the student, the student's response will make sense to the teacher.

One more modification is needed. The behaver's response may seem to be irrational to himself, as well as to another person. In other words, he may not be conscious of the inaccuracy of his perceptions, and if so he cannot understand his behavior either. To go back to the example of the horn player, he was not aware that he regarded the passage as being too difficult for him. We can be certain of this, for if he had been aware of it he would have arranged to be absent from the performance.

We are now down to the kernel of our theme, and are ready to justify the use of the term "Personality Factors," in the title. Inappropriate behavior occurs when perceptions are inaccurate, and inaccurate perceptions are likely to be unconscious. We will dwell mostly on the unconscious ones. Why do individuals have unconsciously inaccurate perceptions? We can loosly say that unconscious perceptions are influenced by personality, but this answer is not good enough. What do we mean by personality? When I put this word in the title I mean something like this: it is the sum total of all the feelings a person can have about himself. The feelings he can have about himself as a man or woman, as a student, as an athlete, as the offspring of his parents, as a memmer of society, to mention a few.

I say feelings, rather than thoughts, in order to emphasize their subconscious nature. These feelings are deeply rooted in a person's past, and we all have them. Our society being what it is, we may easily grow up with feelings of inadequacy in some of these areas. If a stimulating situation touches on an area in which we feel inadequate, the anxiety about our inadequacy may cause an inaccurate perception, and a disorganized response.

Before developing this theme further, we should note that inaccurate perceptions are not troublesome if they are conscious, because they are easily recognized and corrected. This is what happens in a successful learning situation. Here is an example. Imagine a person who had never seen an ice-covered street. He might perceive it as being like asphalt, and his behavior would reflect the inaccuracy of his perception. After a few gyrations he would fall down. However, immediately he would understand the inaccuracy of his first perception, and it would not happen again. He would have learned, and his perception would have become more accurate. In fact, if he were told ahead of time what to expect he would not need to fall down at all, provided, of course, he knew enough language to understand. In other words, a "teacher" could help him to sharpen the accuracy of his perceptions ahead of time, just as when we demonstrate a method of problem solution in a class room. Those with the language equipment and background to understand the demonstration will be able to do a problem like it without "falling down." A person with less understanding will need

to "fall" before his perceptions will be accurate, but if there are no subconscious perceptions distorting his view he will learn from the "falling" experience, because he can see what was wrong.

These ideas can be organized into a definition of learning. In the framework of this trend of thought, I would suggest that learning is a process in which the student responds to a sequence of new stimuli, with continually increasing accuracy of perception. When a mistake is made the inaccuracy of perception which caused it is consciously recognized by the learner, and adjusted accordingly. Thus, when learning is taking place the student's conscious perceptions are slightly more accurate each time a situation arises. Although repeated mistakes may be made, if learning is taking place these mistakes will all be different, however slightly. Emphasis is on the idea that in learning the learner must have an accurate evaluation of his own perceptions which are relevant to the subject.

Learning May Be Inhibited

If he has a subconscious inaccurate perception, which is relevant to the situation, learning may be inhibited. Being unaware that his perception is inaccurate, he can do nothing about it, and he will make the same mistakes repeatedly. In such a case learning is possible only after the inaccurate perception is removed. But its removal will not be accomplished by dealing only with the subject matter to be learned. As we go on I will suggest how it may be possible to help a student escape the bondage of inaccurate subconscious perceptions, and thereby to release him to become aware of, and to deal with, the real problems of learning. I shall also suggest that this phenomenon may be much more prevalent than you may suppose.

We return now to the subconscious perceptions, considering them in somewhat more detail. I will cite an example of a student whose perception I believe was inaccurate and subconscious. At one time I was helping out in a freshman orientation program, leading a discussion group. In reply to one of the students, who had expressed the feeling that in one of his classes there was not enough student participation, I mentioned that I believed most teachers would welcome constructive comments from members of the class. After the class was adjourned one student came to me and said I was wrong. "No teacher would welcome criticism of any kind" he said, with great emphasis. I accepted this as his viewpoint, and discussed it with him at some length, but he was adamant in his belief. We might suspect that he must have had an unfortunate experience with a teacher at some time. If indeed this was the case, he had generalized it to all teachers, and he had no room for any thought that there might be an exception. Note that while he was denying the possibility of a teacher accepting criticism, he was mildly criticizing me. In other words, his action at the time was to some extent disproving his contention. But this did not change his viewpoint, and I believe the reason is that he had a subconscious inaccurate perception of teachers.

Of course, I must admit that I did not know the person well, and I cannot be sure of my analysis, but I think it will be useful to speculate as to what that perception may have been. The speculation is this: that this student felt his relation to teachers to be much the same as a very young child might feel toward his parents—the feeling of being in the presence of an authoritarian, unyielding influence. In the teacher-student relationship he felt subordinate and ineffective.

To go on with this theme, have you ever noted that with some students it is impossible to give a quiz easy enough for them to pass? Easy or hard, the grade is always about the same. We may speculate as to the perception of such a student as he sits with exam paper

in hand. Perhaps in his school experience he became thoroughly convinced that he was a poor student, so that now he feels like a poor student. He literally cannot imagine himself getting a good grade. He would not feel like himself if he did. Perhaps you can remember occasions in your own life where you have not felt like yourself—you would say you felt out of place. It is an uncomfortable feeling, perhaps like a temperance worker would feel if dragged into a beer hall. We do not like to feel uncomfortable, and neither does the student. And what can this do to his perceptions? He cannot read a question and perceive that he knows the answer. His subconscious need to feel like himself—a poor student—causes him to see no relationship between the question on the paper and what he knows. He subconsciously knows the questions are too difficult before he looks at the paper.

There is another possible explanation, based on a somewhat different perceptual distortion. Perhaps, like the student mentioned earlier, he feels that teachers are his authoritarian masters who are "out to get him." He may feel that teachers take sadistic delight in concocting impossible questions. If this is the way he feels, all questions will be impossible to him. He needs to feel dominated and pushed around by the teacher—otherwise he will not feel like himself.

At this point I would like to inject a word of caution. I am not suggesting that all causes of poor student performance can be explained in this way. I am suggesting, however, that effects such as I am describing do reduce our productivity at times, and that in some cases the effects can just about smother all latent abilities.

I have spent quite a bit of time dwelling on the feeling of student in relation to the teacher. This is by no means the only type of feeling we might consider, but it seems to be the most appropriate one, since we are dealing with the learning process. An important distinction must be made, however; I am not talking about a conscious attitude toward a specific teacher, but rather a generalized feeling toward an *image* which the student has, and which image he applies to each teacher. In the earlier example, the teachers who (in the student's mind) would not listen to the student's suggestions were not real flesh and blood teachers; they were the student-created images which he superimposed upon them. Therefore, to him all teachers were alike.

If this sort of distorted generalized image is so important, perhaps we should consider briefly how it can come into being. It is perhaps not surprising that we all have such images to some extent. It is quite common in our feelings toward officers of the law, sometimes toward anyone in uniform, or in government, to cite some examples. These feelings have roots going back to early impressions, gathered when we were too inexperienced to evaluate situations for ourselves. For example, a child needs to be told only a few times that if he does not behave a policeman will "get him" in order for him to have a distorted image of a policeman. He does not know enough of the facts to form an accurate image. And these images can persist literally for a life time. In later life such a person learns more about policemen, but he may still not really be sure that a policeman is a human being, in the same sense that he knows his neighbor is a human being.

I can remember being surprised, as a child, to find that my teacher lived in a house more or less like mine. To me teachers were sort of non-human mechanical people, who perhaps crawled into the walls when the class went home. I felt they didn't have families and relatives.

I am hoping that these examples will have recalled to your minds some similar thoughts of your own. If this is possible it will make my words seem more meaningful to you, and improve our com-

munication. From talking with many persons I am quite sure that feelings of this sort are quite common.

Before going on to discuss some of the ways in which I think we can minimize these effects in the learning situation, let me mention one more example. From my college days I remember the prevalent belief among students, which I shared to some extent, that a teacher's evaluation of a composition or report was based on its bulk. Here again we have the generalized image which was superimposed on all teachers. I did not consciously believe it, but nevertheless I would still feel uneasy about turning in a short, but well done, report. This myth (and I think you will agree with me that it is a myth) is still around our campus. The other day I was talking to a typewriter salesman. He told me that students prefer the large pica type, because with it they produce more pages per composition.

In terms of the total student, I have probably allocated a disproportionate amount of time to the teacher image. Earlier, however, I talked about the feeling toward self; the image of self so to speak. As we go on I would remind you that this is no less important, and perhaps more important. Bear in mind that the student may superimpose upon himself an inaccurate image, in the same way that he can superimpose an inaccurate image on others.

What Can Be Done?

If these ideas are correct, what can we do about it? Theoretically the answer is simple. Get to know each student so well that you can understand how he feels, and so you can understand wherein lie his inaccurate subconscious images; and then patiently and without threat set him on the right track each time his behavior shows that his perceptions are inaccurate. But this is a large order. In the first place, it requires knowing more about a student than he knows about himself. It also requires more individual attention than we can afford in our present educational system. Finally, if we are honest, we must admit that we teachers, as human beings, may have some inaccurate subconscious perceptions ourselves. No private images of ours can be generalized to the students, if we are to help them with their perceptions. As teachers we should examine our perceptions of the students as objectively as possible. We must be free of any subconscious images of students as being immature, stupid, or lazy.

Let us assume that we are "secure in our own perceptions," and therefore that we can be objective enough to be of help. Admitting the impossibility of extensive individual contacts, I would like to suggest that we can apply these principles in our day-by-day dealings with students. We have boiled them down to the following: a student may have subconscious perceptions of the teacher, of himself, or both, which are grossly inaccurate. The question is, can we recognize a distorted image, and if so can we change it? As far as recognition goes, much can be done by observing the subtleties of a student's behavior; by noting when his behavior looks unreasonable to us and then asking ourselves what perceptions might have led to that behavior. I have illustrated this with several of my examples.

Now let us consider what we can do in a situation where the student does have distorted images that need changing. First, and probably most important, he must be accepted as he is, distorted perceptions and all. We do not tell him directly our evaluation of him; he would not believe it. His distorted image will dissolve only through the steady action of day-by-day offerings of evidence from someone with whom he feels comfortable and whom he respects. The moment he is rejected he is again sure that his distorted image is correct, and the distortion is reinforced.

I have one specific suggestion. We

could begin by emphasizing that as teachers we are the students' employees, and that in the discharge of our duties it will be necessary to give certain assignments, and to administer examinations, etc. Many of you may have tried something like this, and may claim that it does not work. I agree that this alone will not work; it is just a start. From my own experience, it seems that it will not work unless it is followed by months of action on the part of the teacher, which action demonstrates uniform adherence to the stated principle. In other words, the teacher has to thoroughly believe it, and live it. I will illustrate what I mean. Suppose I, as a teacher, point out the above principle at the beginning of the term. Later on a student is delinquent and I say to him "I told you this assignment was for your own good; why didn't you do it?" As soon as I say that, the student feels rejected, and he is no longer perceiving the neglected work and formulating a plan to deal with it. Instead, he may perceive the need to defend himself. In fact, it may sound so much like being told as a child that he was being punished for his own good that his response will be patterned after the immature earlier childish response.

Now let us try another response. Suppose I say "I see you were unable to get that work done, could I be of help to you?" Or perhaps, if there is no time to give help, I could say "I see you were unable to get that work done. I understand how it is sometimes difficult to get things done, but of course you realize I cannot give you full credit, because it is late. I am sorry." I think you can see that there is much less threat to the student in either of the last two statements. A slight difference in wording can make a big difference in the amount of acceptance felt by the student. As another example, consider the two replies "don't let it happen again" and "I hope it won't happen again." The first statement rejects the student; whereas the second one accepts him.

Possibly you may feel that I am blowing this up to unreasonable proportion; that a student could not be profoundly affected by such minute distinctions. I would agree that a single teacher response, one way or another, may not make much difference. It is the cumulative effect of dozens or hundreds of them that can be important. If the component is always in the direction of acceptance, the effect will be cumulative. It is like an errosion process.

You will recall that I said the teacher has to live according to these principles. He does not have much time to think out the responses, although at first it may be necessary to do so. After a while they can become automatic, but until then a wrong one may sometimes slip out. I will plead guilty to having made many mistakes. Once, when a student missed something on a quiz which had been explained just the day before in class, I said "you should have gotten that; I just explained it yesterday. See how simple it is." How much more helpful it would have been to have said "It's too bad you missed that; I understand how easy it is sometimes for the simplest things to evade us."

Acceptance of the student by the teacher is the corner stone of the suggested procedure. If a student fails to get his work done there is a reason which is very valid to him, even though to the teacher it might superficially appear to be sheer laziness. This we must accept. Maybe at a later time the cause will have disappeared, but at the time it is with the student we cannot shame him away from it.

I have one more important observation to make. Earlier I spoke about how we might determine whether a student has misperceptions that are disturbing him. Now that we have considered what sort of treatment to give, we see that it would not hurt anyone. Therefore, it is not so important to be sure which of the students need help. All members of the class can be treated with acceptance, and

the students will draw from their experience and contacts with the teacher to the extent of their needs. However, this would be a minimum program. Specific inaccurate perceptions of individual students should be heeded whenever recognized.

I think by now I have given you enough examples to show you what I mean. If, in the day-by-day contacts you really accept the student as he is, and act in terms of his needs, which means doing your best to learn what are the incorrect perceptions to which he is reacting, then, as the weeks pass, he may gradually readjust his image of you, and he will finally believe what you said when you said that you were his employee, working for him.

A somewhat oversimplified, but useful, concept of what I have been talking about is to say that it is a method for reducing the "effective" size of the class. We all know that teaching is more effective in small classes. No small part of this is probably due to the close relationship between student and teacher in a small class, which permits these desirable sharpenings of perceptions to take place automatically. Thus, in a sense, I am suggesting that we can improve teaching in a large class by "artificially" generating some of the conditions which naturally prevail in a small class.

Based on Theory

For the most part you have noted that my recommendations are based on a theory. I have not presented objectively evaluated experimental evidence in support of this theory; but subjective evidence obtained so far is encouraging. I would like to cite one recent case which I think is significant because the student in question was rather typical. At the beginning of the term this student was mainly interested in impressing me. He had a slight acquaintance with the subject, and he liked to flaunt it by asking irrelevant questions on advanced work. The first quiz showed very little grasp of the subject; he apparently did not want to bother with fundamentals. I suspected that he perceived a teacher as someone to impress, and this was the cue to my response to him. I received him warmly, and within myself accepted him as he was. I liked him. However, I avoided giving him support in his attempts to impress me, and repeatedly tried to direct his attention to the subject matter of the course. During the course of the term the change in his behavior was very marked, but it occurred slowly. No change was apparent in the first month, but gradually his questions became more pertinent, and less frequent. His work improved. He moved from near the bottom of the class to better than average by the end of the term. Of course, I must admit that this is a subjective evalution, and there is no certainty that the results were due to my method of handling the case. However, it seems that the number of successes of this sort has increased since I have modified my classroom responses. It is my hope that objectively evaluated experiments may someday be carried out which will test these ideas more accurately.

Summary

In closing, I would like to summarize the main points of this thesis. Every student is an individual who probably has some distorted perceptions relating to the learning situation. These distorted perceptions lead to ineffective behavior, because he responds to these subconscious perceptions, rather than to the job of learning. The teacher can be helpful by recognizing these possibilities, always attempting to behave toward the student in such a way as to improve the accuracy of his perceptions. In order to have this sort of effect on the student it is necessary that he be treated in a warm and accepting manner. As used here the word "accepting" means accepting recognition of the student and his distorted attitudes; recognition that his behavior is strongly influenced by these attitudes, and

that they will change slowly if all. It does not mean coddling the student. I am not recommending a "soft" attitude in the sense that such an attitude would remove requirements and give the student free reign to do as he pleases. Work demands on the student can be as rigid as desired, within limits of possible accomplishment; but the above principles governing behavior toward the student can be applied within whatever administrative structure is used. For example, penalties can be involved for late work, but they should not be accompanied by inappropriate remarks.

Finally, I would like to say that anyone trying these ideas would do well to arrange to have one or more collegues working along the same lines, so that problems that arise can be freely and frankly discussed in periodic staff discussions. This can help to bring out some of the subtleties which will not be apparent from my words alone, and it will also help you to inspect your own perceptions and possibly to make them more accurate. To the extent this is done the more automatically will appropriate responses come to mind when dealing with students. In other words, what I am saying is that one of the most effective ways for a teacher to learn this type of behavior is for him to participate in group discussions with others, so that he may continually reorient himself in the light of insight gained as he reacts to his colleagues and to himself as he recites his experiences.

College Notes

A department of metallurgical engineering has been established in the **New York University** College of Engineering. Acting chairman of the new department will be Dr. John P. Nielsen.

A Motion and Time Study Intensive Course, offered by the Department of Industrial Engineering of **Washington University** at St. Louis, will be presented from June 8th through June 17th. This course is intended for personnel desiring a basic introduction to Motion and Time Study. Material covered will be presented with emphasis on setting up correct methods before work is in existence as well as techniques for the improvement of existing methods and procedures. The objectives of the course will be to prepare the attendee to (1) apply Motion and Time Study in his own organization and (2) train others in his company in the principles of Motion and Time Study.

Several visiting speakers will present their experiences with the application of Motion and Time Study and with related fields in industry to further enhance the material of the course. The course is under the direction of Dr. Gerald Nadler of the Department of Industrial Engineering at Washington University. Other members of the intensive course teaching staff include industrial personnel as well as university faculty.

This course is being presented with the cooperation of the St. Louis Chapters of the American Institute of Industrial Engineers and the Society for Advancement of Management. For further information concerning course content, instructors, and registration, write to the Department of Industrial Engineering, Washington University, St. Louis 5, Missouri.

The appointment of Karl B. McEachron, Jr. as Dean of the Undergraduate School of **Case Institute of Technology** effective on June 1, 1955, has been announced. Dean McEachron will assume a portion of the duties now held by Dr. Elmer Hutchisson who has been Dean of the Faculty at Case since 1945. Dean Hutchisson will devote his full time to his duties as Dean of the Graduate School and Director of Research on June 1, 1955.

Report of the ECAC Military Affairs Committee on the Study of ROTC Curricula in Engineering Colleges

Fall 1954

Submitted by

ELMER C. EASTON, *Chairman*

At the request of the Evaluation Committee of A.S.E.E. and other interested groups, the Military Affairs Committee of the Engineering College Administrative Council prepared and circulated an ROTC Questionnaire consisting of three parts. The covering letter explaining the questionnaire is shown as Exhibit 1 of this report. The questionnaire forms are illustrated in Exhibits 2, 3, and 4 where the summaries of the replies are given.

Questionnaires were mailed to 145 engineering colleges on September 27, 1954. By November 1, 1954, when the results were analyzed, 89 usable replies had been received.

Part A of the questionnaire was used to determine current practice with regard to the granting of credit for ROTC courses. The replies showed that the Army General, Air Force General, Combat, and Specialized programs are handled in a fairly uniform manner. The credits allowed in the Navy sequence are slightly different.

Almost all of the colleges offering Navy ROTC programs have 12 credits of basic and 12 of advanced courses in the ROTC sequence. Approximately 10 per cent of the colleges allow no ROTC credit toward the B.S. degree in engineering. The averages allowed (counting all colleges) are 8.0 credits for the basic courses and 9.6 credits for the advanced courses. Approximately 57 per cent of the colleges do not permit advanced ROTC degree credits to be substituted for engineering courses. The average permitted (counting all colleges) is 2.8 credits. Approximately 24

TABLE 1

NUMBER OF INSTITUTIONS ALLOWING INDICATED ADVANCED ROTC DEGREE CREDITS TO BE SUBSTITUTED FOR ENGINEERING COURSES (NAVY ROTC)

Number Inst.	Credit Hours
12	0
1	1
2	3
3	6
1	10
2	12
(Total 21)	(Average 2.8)

TABLE 2

NUMBER OF INSTITUTIONS ALLOWING INDICATED ADVANCED ROTC DEGREE CREDITS TO BE SUBSTITUTED FOR HUMANISTIC-SOCIAL COURSES (NAVY ROTC)

Number Inst.	Credit Hours
5	0
1	1
5	6
3	9
7	12
(Total 21)	(Average 6.66)

TABLE 3

NUMBER OF INSTITUTIONS ALLOWING INDICATED ADVANCED ROTC DEGREE CREDITS TO BE SUBSTITUTED FOR ENGINEERING COURSES

Army General		Air Force General		Combat		Specialized	
No. Inst.	Cr. Hrs.	No. Inst.	Cr. Hrs.	No. Inst.	Cr. Hrs.	No. Inst.	Cr. Hrs.
21	0	33	0	14	0	20	0
2	1	5	3	1	3	1	3
3	3	10	6	1	4	1	4
4	6	1	8	3	6	5	6
1	9	1	10	2	12	1	9
2	12	5	12	(Total)	(Average)	1	10
(Total)	(Average)	(Total)	(Average)	(21)	(2.33)	2	12
(33)	(2.06)	(55)	(2.78)			(Total)	(Average)
						(31)	(2.58)

per cent of the institutions do not permit the substitution of advanced ROTC degree credits for humanistic-social courses. The average allowed (counting all colleges) is 6.66 credits. The variation in practice with regard to the last two items is shown in Table 1 and Table 2.

Among those institutions offering Army General, Air Force General, Combat, or Specialized ROTC programs, approximately half have a basic ROTC sequence of 4 credits, while the others have a basic program of 8 credits or more. The average is approximately 6.25. Most of the colleges have 12 credits in the advanced sequence. The average is almost exactly 12. About 11 per cent of the colleges allow no ROTC credit toward the B.S. degree in engineering. The averages allowed (counting all colleges) are approximately 5.2 credits for the basic courses and 9.05 credits for the advanced courses. Approximately 63 per cent of the colleges do not permit advanced ROTC degree

TABLE 4

NUMBER OF INSTITUTIONS ALLOWING INDICATED ADVANCED ROTC DEGREE CREDITS TO BE SUBSTITUTED FOR HUMANISTIC-SOCIAL COURSES

Army General		Air Force General		Combat		Specialized	
No. Inst.	Cr. Hrs.	No. Inst.	Cr. Hrs.	No. Inst.	Cr. Hrs.	No. Inst.	Cr. Hrs.
8	0	12	0	5	0	9	0
1	1	1	1	1	3	1	3
1	3	2	3	4	6	7	6
3	4	2	4	1	9	3	9
9	6	21	6	9	12	10	12
2	8	1	8	1	14	1	14
2	9	4	9	(Total)	(Average)	(Total)	(Average)
6	12	11	12	(21)	(7.53)	(31)	(6.65)
1	16	1	16				
(Total)	(Average)	(Total)	(Average)				
(33)	(5.8)	(55)	(6.05)				

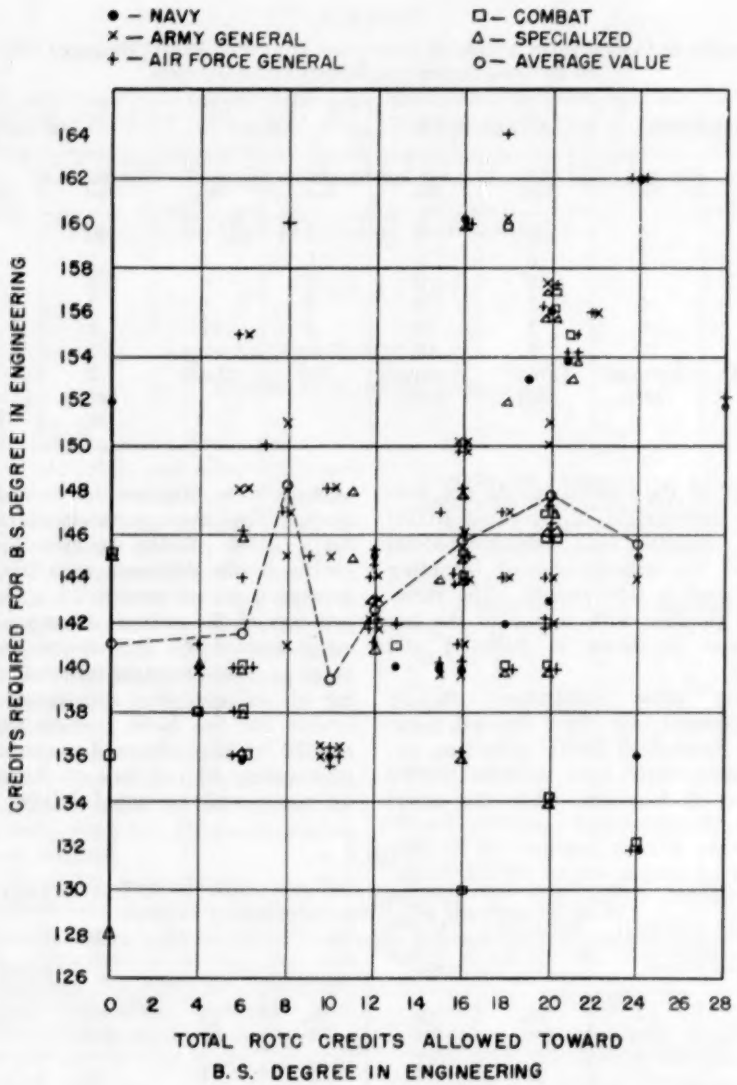

FIGURE 1.

credits to be substituted for engineering courses. The average permitted (counting all colleges) is approximately 2.48 credits. Approximately 24 per cent of the institutions do not permit the substitution of advanced ROTC degree credits for humanistic-social courses. The average allowed (counting all colleges) is approximately 6.3 credits. The variation in practice with regard to the last two items is shown in Table 3 and Table 4.

Figure 1 illustrates the relation between the total ROTC credits allowed toward the B.S. degree in engineering

(Column 6 of Part A of the questionnaire) and the total number of credits required for the degree. It is obvious that there is no uniformity of practice. The average number of credits required for the B.S. degree appears to rise in an erratic manner from about 141 in those colleges which allow no ROTC credits to be used toward the degree to about 146 in those institutions which allow 24 ROTC credits to be used toward the degree. Undoubtedly, some institutions treat the ROTC credits as additions to a basic program of other subjects. In these colleges the total credits required for the degree is substantially higher than it might be if the ROTC program were not available to the student. On the other hand, it is clear that some colleges have a low total requirement for the degree despite a high permissible ROTC content.

TABLE 5

PERCENTAGE OF ADVANCED ROTC SEQUENCE JUDGED TO HAVE CONTENT COMPARABLE TO ENGINEERING AND HUMANISTIC-SOCIAL COURSES OF COLLEGE LEVEL

Navy	59.9%
Army General	47.3%
Air Force General	49.0%
Combat	42.2%
Specialized	45.7%

The answers to Part B of the questionnaire indicate that the percentage of the Advanced ROTC sequence judged to have content comparable to engineering and humanistic-social courses of college level varies as shown in Table 5. A further breakdown is given in Exhibit 3.

When answering Part C of the questionnaire, those institutions which have converted from a specialized Army Branch Program to Army General Military Science indicated that the new program is at least as good as, and in some respects better than, the old. Very few indicated that the new program was poorer than the old. The distribution of replies is shown in Exhibit 4.

The members of the Military Affairs Committee who participated in this study are David L. Arm, Jess H. Davis, Paul E. Hemke, Lee H. Johnson, John H. Lampe, J. F. Downie Smith, Harold E. Wessman, Elmer C. Easton, Chairman.

EXHIBIT 1

ENGINEERING COLLEGE ADMINISTRATIVE COUNCIL

MILITARY AFFAIRS COMMITTEE

September 27, 1954

To All Deans of Engineering.
Gentlemen:

There appears to be need for reliable information regarding (1) the amount of credit being granted for ROTC courses, and (2) the opinion of engineering educators concerning the educational value of the advanced ROTC courses. The Military Affairs Committee of E.C.A.C. has been asked to obtain this information. Accordingly, the enclosed questionnaire is being sent to you with the request that you please fill it out and return it not later than October 23, 1954. A copy of the summary of the answers will be sent to all who reply.

Part A of the questionnaire refers to credit granted for ROTC courses. If the allowable credit differs among various engineering curricula, please show the range of values in the table.

Part B concerns the evaluation of the course content of the *advanced* ROTC courses. Please indicate the percentage of the total advanced ROTC program which, in your opinion, is equivalent to (1) humanistic-social courses of the college level, (2) engineering courses, (3) vocational training, (4) extra-curricular activities. For example, if you believe that one-quarter of the advanced program has educational content similar to that gained through participation in extra-curricular activities, place the number 25 in column 4. When

answering Part B, please give the evaluation as you think it *should* be, not necessarily as it is at your institution.

Part C has been included partly to aid the Engineering Manpower Commission Sub-committee on the Branch General Program and to obviate the necessity for a separate questionnaire from that group.

If you have any questions regarding interpretation of the questionnaire, please write write to me for clarification before completing the form.

Sincerely yours,

ELMER C. EASTON
Chairman, Military
Affairs Committee

College of Engineering
Rutgers University
New Brunswick. N. J.

EXHIBIT 2

SUMMARY OF REPLIES TO E.C.A.C. MILITARY AFFAIRS COMMITTEE
ROTC QUESTIONNAIRE, PART A

Fall 1954

Credit Allowed for ROTC Courses

Prepared by: Dean E. C. Easton, Rutgers University, New Brunswick, N. J.

Type of ROTC Program	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Replies
	Total credits* in ROTC sequence			ROTC credits* allowed toward B.S. degree in Engineering			Advanced** ROTC degree credits which may be substituted for		
	Basic	Adv.	Total	Basic	Adv.	Total	Eng'g courses	Hum.-soc. courses	
Navy	12.0	12.0	24.0	8.0	9.6	17.6	2.8	6.66	21
Army General	6.05	12.4	18.45	5.4	8.9	14.3	2.06	5.8	37
Air Force General	6.36	12.4	18.76	5.36	9.06	14.42	2.78	6.05	55
(a)	6.51	11.7	18.21	5.0	9.4	14.4	2.33	7.53	21
(b)	6.55	11.2	17.75	4.87	9.0	13.87	2.58	6.65	31

(a) Any *one* combat branch such as Infantry if offered at your institution. (Replies mostly Infantry.)

(b) Any *one* specialized branch such as Signal Corps. Please insert name of branch. (Replies mostly Engineer Corps.)

* Give credits in semester hours. If you operate on the quarter system, please multilpy by 2/3 to convert quarter hours to semester hours.

** If credit for *Advanced* ROTC is allowed toward the B.S. degree in Engineering, please indicate how many of these credits may be offered as substitutes for engineering courses or humanistic-social courses. For example, if a student may offer x credits of Advanced ROTC in place of either engineering or humanistic-social courses, place x in both columns. If he may offer x credits only in place of humanistic-social courses, place x in the second column and o in the first.

What is the total number of credits required for a B.S. degree in Engineering? *146* Is Basic ROTC required [57] or voluntary [32] in your institution? Is your institution a Land-Grant college? Yes [40] No [49] (89 replies)

EXHIBIT 3

SUMMARY OF REPLIES TO E.C.A.C. MILITARY AFFAIRS COMMITTEE
ROTC QUESTIONNAIRE, PART B

Fall 1954

Prepared by: Dean E. C. Easton, Rutgers University, New Brunswick, N. J.

Evaluation of Course Content
Two Years of Advanced ROTC

Percentage of work that has content comparable to

(1) humanistic-social courses of college level
(2) engineering courses of college level
(3) vocational training not acceptable for college credit
(4) extra-curricular activities, not usable for college credit

Type of ROTC Program	Hum. Soc. (1) %	Eng. (2) %	Voc. (3) %	Ext. curr. (4) %	Replies
Navy ( )*	24.2	35.7	27.6	12.5	19
Army General	36.1	11.2	30.1	22.6	30
Air Force General	37.0	12.0	27.0	24.0	48
(a)	36.1	6.1	33.1	24.7	13
(b)	21.1	24.6	37.3	17.0	26

* Indicate option such as Line, Marine Corps, Supplys Corps. (Replies mostly Line.)
(a) Any one combat branch such as Infantry. (Replies mostly Infantry.)
(b) Any one specialized branch such as Signal Corps. (Replies mostly Corps of Engineers.)

Was the above evaluation made by the engineering dean [45], another administrative officer [7], or a faculty committee [12]?

EXHIBIT 4

SUMMARIES OF REPLIES TO E.C.A.C. MILITARY AFFAIRS COMMITTEE
ROTC QUESTIONNAIRE, PART C

Fall 1954

Prepared by: Dean E. C. Easton, Rutgers University, New Brunswick, N. J.

If you have converted from a specialized Army Branch Program to Army General Military Science, please indicate how the General Military Science Program compares with the former specialized one in the following respects:

(1) In meeting the educational needs of your engineering students—the General Military Science Program is

[14] Better

[13] About the same

[2] Poorer

(29 replies)

(2) In maintaining the interest of your students in the Army ROTC and in influencing them to enrollment in the advanced ROTC—

the General Military Science Program is

11	Better
13	About the Same
4	Poorer

(28 replies)

(3) In terms of interest in the Summer Camp Program first given on a General Military Science basis in 1954—

the General Military Science Program is

11	Better
9	About the Same
3	Poorer

(23 replies)

(4) The Army General Military Science program has replaced the following specialized program(s): *Infantry—21; Engineers—12; Signal Corps—9; Ordnance—6; Quartermaster—4; Artillery—7; Transportation—2.*

Graduate Study in Building Engineering and Construction*

By WERNER H. GUMPERTZ

Assistant Professor of Building Construction, Massachusetts Institute of Technology

The decision as to what shall happen to graduate study in building engineering and construction or any other engineering science depends only partly on us, the educators of today and tomorrow. This battle is being fought right now on the level of kindergarten and between the kindergarten teachers and the parents of the boys who will be our graduate students some sixteen years from now. I recall some sessions that I had as a member of the faculty of the Bridgeport Engineering Institute where the humanities instructor was at the same time a teacher of English in the local high school. All of the other instructors gleefully descended upon him and criticized him for the poor preparation that our students had received in English. To our surprise he immediately passed the blame on to the grade school teachers and advised us that we would not find the culprits there either, that the culprits were to be found on lower level, the kindergarten. The kindergarten teachers in turn were blaming it all on the parents.

Before I start trying to make a definition of what graduate study in architectural engineering is and what it means, I think I owe you an explanation as to why I think that this battle will be fought in the kindergarten. The sad fact is, and one that most of you are only too familiar with, that the standards of primary and secondary education are being reduced to an ever increasing degree. It seems to be our policy that the only way to improve education is to broaden the base ever more and to give an academic type of education to every last boy and girl in this country regardless of whether he or she is qualified, or even interested in receiving this education. Obviously, it is impossible to keep any kind of standard if such a policy is to be followed. Of course every boy and girl should have an opportunity to get the education for which he or she is best suited, regardless of social or monetary standing. However I believe that if we want to check the trend toward ever broadening and flattening academic education, we must admit that the same type of education is not for everybody.

You need not be told how little preparation there is right now in English, report writing, speaking and spelling, not to talk about such complicated matters as arithmetic, algebra and trigonometry. Our high schools nowadays give the student an extremely wide choice of subjects, and some of the basic disciplines are not among the required subjects. On the other hand, a lot of new courses are available to the student who is interested in them, such as home economics, creative dancing, sex education in three easy lessons, and credits given for personal hygiene. Now the worst of the results of such a policy of trying to give everybody exactly what he thinks he wants and paying no attention at all to a proper development of the young mind, is not the ignorance that we so woefully find in our freshmen in colleges. The greatest trouble is that these young minds are

* Presented at the Architectural Engineering Division, ASEE Meeting, University of Illinois, June 17, 1954.

never required to seriously fight with an intellectual problem. Everything is made easy for them, such as alternate solutions, true and false questions and escapes of many other sorts. Now in the middle ages in Europe there was a mythical device called the funnel of Nuremberg; this funnel was a wonderful invention. It could be placed into a hole which had been judiciously drilled into a student's skull, and wisdom and knowledge could be poured into that funnel and into the pupil's brain by the quartful if not the gallonful. It was a painless or a king's way to learning. Unfortunately, the recipe to this wonderful process has been lost since and we will have to deal with the problems of learning in a more prosaic way. There is no doubt about the necessity of instilling into young minds a mental discipline which faces them with the unpleasant facts that in order to learn you must work, and if you want to achieve something, it takes effort and pain to do so. There is no better satisfaction than having been able to achieve something through hard work. Now while luckily learning by rote has gone out of the window and I hope forever, there are many ways in which the basic human values, the humanities, the common heritage of thousands of years of human culture must be given to our children as well as the result of thousands of years of ever increasing achievement in the sciences. This is, of course, primarily a problem for the elementary and high school teacher; however, we must be quite aware of it because we are getting the results of that primary and secondary education.

Direct Bearing on Graduate Study

The reason why I am bringing this up at length is because this has a direct bearing on graduate study. The question has come up recently more and more often exactly what graduate study is supposed to accomplish. In order to make a competent professional man these days takes more rather than less knowledge, and there is no miracle yet with which we can increase the amount of learning that we can give these men in four years. Unfortunately, many educators are thinking about the easy way out, that of adding a fifth or sometimes a sixth year to the engineering curriculum. Others try a solution in a very similar way by making a liberal arts course a prerequisite for engineering school such as is now the case with medical education. There is no excuse for this. I feel that high school should teach such things as the handling of one's native tongue, maybe one or two foreign languages, an ability to deal with ideas, and a cultural heritage enabling one to be more than just a slide-rule engineer.

Men are becoming older and older by the time that they have prepared themselves for a professional career. It was not so long ago when a bachelor of science degree was sufficient for a successful career in any field of engineering, including the academic field. We all know that this is no longer the case. By the time you are a Ph.D. or Sc.D. you are probably twenty-eight years of age and you probably have to work for a few more years until you finally can take over the responsibilities that go with having a family. This is morally and socially a questionable situation. A young man is physically ready to be married when he is seventeen. He probably is emotionally ready when he is twenty-three. If we make this young man dependent upon his family and unable to respectably get married and support his family as it has been the custom for untold thousands of years, we are committing a crime on that generation. There is absolutely no excuse for keeping the student in school for such a length of time simply because we fail to give him the education that he is entitled to in the first place. For the intelligent general practitioner of engineering, a bachelor's degree should give a full and proper preparation so that he will be enabled, after due experience, to become a useful and creative member of his profession,

without being required to be ashamed of the fact that he has no higher degree. Graduate study should be reserved for serious specialization in a technical field. It should not be simply an extension of more and more involved undergraduate courses. Instead it should have a very definite goal towards a professional education which is usually described as a desire to go into research, development, or teaching.

This raises the necessity for reviewing our attitude towards the way in which graduate school is being taught. A lot of devices which are quite useful in connection with undergraduate courses, are mechanistically applied to the graduate school as well, and I think that it would be very useful to review this situation from the bottom up. I would evaluate every teaching technique, device and administrative organization which is used to educate our young men toward the M.S., Ph.D., or similar degrees. Our emphasis should be in a different direction. For instance the responsibility of the mature student to actively plan his own curriculum and to be responsible for his own actions without being spoon-fed cannot be escaped, if you truly want to give the student the highest education. This probably means that to a large extent the students themselves should plan features of courses of instruction in various disciplines, and should be their own masters as to how they use their time to a much larger extent than they are now. There are definitely dangers in this procedure, because a weak character might very well take the easy way out, select a "snap" subject to write a report on, or to delay the assignment until the last minute, when it cannot be done to the satisfaction of the instructor. The student should, therefore, together with this new liberty, be willing to accept the responsibility to stand or fall with the things he himself is doing in graduate school.

There is further need for us, as educators, to review carefully every subject that we are teaching in graduate school, and to evaluate its contribution. Since it is obviously impossible to teach a man everything about his profession, and since it is probably even more ridiculous to teach him more and more about less and less, until he knows everything about nothing, we cannot equip him to deal with every situation that he will encounter, simply by telling him the solution of all possible problems. The only efficient alternative is to develop in the graduate student a mental discipline and a mental approach to problems which, together with his basic training in his graduate studies, will enable him to approach successfully any problem he may encounter.

Need For More Basic Theory and Research

Looking at the problem from the standpoint of the building industry, we must ask ourselves what the most important possible contribution of the college trained, and especially of the engineer with an advanced degree can be. It seems that despite its size and importance, the construction industry is not too progressive in regard to research. Most achievements in this field have been accomplished by a few lone individuals, who have sometimes worked on the principle of trial and error. Compared to such other fields as medicine, agriculture, chemistry, business administration and pharmacology, the progress in our own field has been rather hectic, disorganized and more or less accidental. Most of our competent contractors, who know how to put up a workable building, do not know exactly why their methods will work. Yet they work sometimes better than the architect's idea. The architect might have noble ideas, but he is sometimes without the necessary experience to choose the correct materials and the combination thereof to obtain a workable building. I was recently retained by a client who had a house built for him by an experienced builder. One foundation wall of that house had collapsed three different times,

and each time rebuilt by the builder. In each instance the builder failed to realize some of the most elementary facts of engineering. If such experienced man could commit a foolish step three times without gaining an understanding of what was wrong, I wonder how the whole industry can ever progress efficiently without having a much more serious approach to basic theoretical principles and a broader acquaintance with all aspects of building. Building engineers cannot be onesided and be satisfied only with utilizing existing materials, with adding a new twist to the design of structures, or with figuring out a better way of handling the construction job. They must be well trained to understand the interrelationship of these various aspects. I feel, therefore, that our most important contribution can be to change the haphazard approach to the problems of the building industry to a more systematic one, and to train a new generation of building engineers who can approach the problem from a mature and well rounded viewpoint which goes far beyond the ability to analyze. Their task is to synthesize.

Synthesis Needed for Professional Achievement

The most important task is to wipe out the many lines of division separating the various disciplines from each other. I have found that even among the undergraduates the lack of synthesis of the many courses of instruction is painful, and often felt so by the students. In case of a graduate student there is even more need to create a whole out of parts. The number of graduate students in our department is small enough that we can make arrangements to combine certain classes. Seminars can help to understand the problems that are faced by the industry, and which cannot be compartmentized the way that a college catalogue might be compartmentized.

This synthesis becomes of even greater importance when we realize that ours is not an exact science, and that we must be in constant touch with the field. To me this means among other things, that the instructor himself must be engaged in a certain amount of consulting to bring ever new problems to pose, and to get ever new solutions to fertilize his own thinking, and that of his students. However, sometimes this might not be possible, or the instructor's consulting work might be too specialized to be of direct use to the students.

In such situations, the use of outside speakers might be considered. As an example, I should like to refer to my experience with a course in building management. This course is designed to train graduate students in the management of existing buildings with all its aspects; the knowledge of structural engineering and construction methods and construction management is a prerequisite. As can be expected, no useful text has so far been found which fits exactly for such a course. Our sources are taken from law, business management, books on engineering valuation, courses of real estate management, labor relations, and insurance manuals. Since it is impossible for the instructor to be an expert in all of these fields, I thought it best to invite men from the field to address the students. One of the leading appraisal engineers fortunately volunteered his services for this course and he gave an excellent course of instruction in engineering valuation. He used a building which he was in the process of evaluating as an example, and had the students work out the problem independently of his own studies. To our delight we found that the students had produced a good looking and mature paper, the findings of which were checked by the engineer himself and found to be very similar to his own. This showed not only that the students had learned a lot from this approach, but also that they could be trusted to produce an efficient piece of work under actual conditions with practically no supervision. This would have been impossible without going to the building in question and having a long and interesting bull session on the

various aspects of land taking. Problems of foundation and structural engineering also had to be considered. The result was a paper containing essential ingredients from several distinct but related disciplines.

Other lecturers in this course included real estate men who discussed problems of managing the different types of real estate, each one with which the speaker himself was familiar. Maintenance engineers of several organizations such as schools and department stores lectured on their specialty, the secretary-treasurer of the local building maintenance union of the A. F. of L. discussed labor problems, and several instructors from the M.I.T. Department of Economics dealt with problems of the general national economy, pricing and financing. The remaining hours were utilized to correlate the information that the students had received from the guest speakers and to make sure that one organic whole was the result. Various papers were written by the students, utilizing the information thus gained. The students had only the most elementary guidance in writing these papers, as if they were consulting engineers, i.e., without outside help. This confidence in the students has been amply repaid with intelligent and interesting papers.

Using outside speakers is a highly promising but at the same time dangerous procedure. I have found time and again that men who had achieved stature in their own field in building construction, who were excellent men to talk with, who had intelligent ideas, froze up as soon as they came to the class because they were over-awed at lecturing at a technical institution. They felt called upon to be highly formal, to be as "theoretical" as possible. Consequently the primary purpose of their coming, that of giving the benefit of their composite experience, was sometimes lost in this formality. It has been difficult to get these men not to worry about a polished lecture, but rather to bring the realities of professional practice into the classroom. However, using about 70 per cent outside professionals and about 30 per cent faculty from other disciplines, I feel that there has resulted the nucleus of a workable course that is realistic to the students and which brings the various points of view. I myself have learned a great deal from hearing experts in the various fields. This year I wrote a full set of class notes, using student papers and my own notes taken during the guest lecturer's hours, and added some of my own ideas to it. I am citing this as an example of how a text can be fashioned from independent work of students and from information given by outside speakers.

Professor Voss, the former head of this department, is at this moment writing a paper which will eventually become a book on advanced construction management. He himself is using his very extensive knowledge of the building construction field to enumerate for class notes (and later on for a book) the things which are usually passed on only informally, and very often inadequately, in construction firms', and engineers' and architects' offices. I, therefore, have high hopes that this synthetic approach will eventually produce a set of class notes which will be truly useful for graduate study.

Course Content

I shall try to summarize some of the thoughts that come into my head regarding how a successful graduate study should be separate and distinct from similar undergraduate courses. Needless to say, the course content itself should be on a higher plane and more difficult. There should be a minimum of help to the students, and their success and failure should depend primarily on their own initiative and ability. As far as possible, a larger latitude should be given to the students in choosing the subjects to be discussed. There are both experienced and inexperienced students, and the

instructor should be flexible to a reasonable degree, to allow the substitution of certain subjects for others if this seems to be more useful. Sometimes the problem of varied experience in the students' background can be solved by giving different assignments.

As to the specific conduct of the classes themselves, here are my ideas of how the problem could be approached:

(1) *Preparation.* Each graduate student should have sufficient preparation in the undergraduate subjects to be able to handle the graduate subjects without any trouble. At times this will mean that a man who has received his degree from another institution will be required to take a great number of undergraduate subjects, including those of the sophomore and junior years. While this might be unpleasant for the graduate student, it is more useful to him in the long run to catch up on the prerequisites on which the graduate courses of study have been based.

(2) *Examinations.* In graduate school the usefulness of quizzes is dubious. Every year I go through the mechanics of giving my graduate students quizzes, although our classes usually include less than six, or at the most ten students. I have yet to find a case where any written examinations have modified the original impression I received about the student, based on his performance in class and from the papers he was required to write. One of the reasons why we do require quizzes is that M.I.T. still works on an arithmetical grade system, including cumulative ratings. This method incidentally is now under attack on the undergraduate level, and a faculty committee is considering a proposal to drop the cumulative rating of students, because it makes the students too competitive without achieving any serious educational purpose. I myself am wistfully hoping that in the not-too-distant future the graduate school will drop requirements for quizzes and grades entirely, and will be satisfied with a composite judgment of the various instructors as to whether a certain graduate student has achieved his goal or not. This is undoubtedly a more difficult thing to achieve than our present grading system; however, I believe that much better judgment can be reached by such conference methods and by a more thorough evaluation of the individual's capabilities in all fields combined. Note here, however, that I do not believe that we should lower our standards in any way; on the contrary, I think that the work of the student (as it must be evidenced in other ways) should be severely evaluated in order to make sure at all times that it is of graduate caliber.

(3) *Reports.* For this reason, reports are in my opinion the heart of the student's work in class. Such reports should be preferably of the student's own choosing in content, and should, of course, be related intimately to some phase of the subject which is being taught in the particular course. The student should be expected, after an initial conference with the instructor, to carry through his paper by himself, and regardless of whether it is a library or field study, he should use his own resources in order to obtain the necessary information and correlate it in his own way. Once the student turns in his report, he should be required to address the class and tell of some of the essential findings of his report. This means not only that the class as a whole gains the advantage of the additional information, but that it teaches the student to relate himself to other people. Thus he learns not only the information contained in the paper, but that it is almost equally important to be able to transmit ideas to other people.

(4) *Seminars.* The natural outgrowth of this type of paper is the seminar type course. I now have plans for a new seminar in construction management which will start next spring. We hope here to obtain as guests some of the leading men in the construction industry and related fields in this area. The seminar will probably take place at least partially at night, in order to enable the various outside men to attend these meetings

without difficulty and without having to cancel their appearance because of other commitments. There will be no fixed curriculum and the students themselves are expected to contribute a major part to the success of the seminar. Discussions alone are projected and no formal addresses are expected to be made by anybody. This will, I hope, involve each student intimately with the problem itself and with the men who have been handling these problems successfully for years. In some of the meetings the students will be expected to organize the meeting itself and to contribute enough useful information to make this meeting worth while. In such cases some of the outside men will be used as arbiters or evaluators to tell the students and myself whether our contribution has been a positive one. The participation of this type will not only be useful for the students but it almost certainly must contribute heavily to the judgment of the instructor in arriving at a decision as to whether each individual student has reached the goal of the course.

(5) *Coordination with other courses.* In the coordination with other courses we probably have not done as much as would be desirable. It is readily understood that problems of instructors' schedules and meeting times are still formidable. However, I hope that with time we will be able to work out a system where the instructors of the various disciplines such as materials, structural engineering and construction methods will be able to give joint classes so that the students will be in a position to see how all the disconnected pieces of information that they have acquired for years are carefully put together by professionals. This is the one thing which we do not teach in undergraduate school and the one thing which I believe would be most useful for the graduate student. After all, when an engineer graduates, after a few years of experience he will have to do just that—combine his knowledge in many fields—and since we are in the fortunate position of having experts in so many different fields, the natural consequence would be to utilize the combined knowledge of these men in one combined meeting with the students.

(6) *Case method.* The next natural step is to the case method itself. Enough has been said in the *Journal of Engineering Education* about the case method to give it serious attention. However, the compartmentization of all courses of instruction so far has made the application of the case method somewhat difficult. However, the few feeble attempts that I have made in the direction of the case method approach have given me hope that such an approach would be very fruitful to graduate students.

This certainly includes outside work. I have mentioned the example of how a valuation engineer took our class to a building which had to be evaluated because of a land taking by the Commonwealth of Massachusetts. I can think of a number of similar situations where actual problems are at stake. Such problems could be dealt with by students, utilizing their knowledge in the various fields of study. The advantage of such a procedure is obvious. The students will gain an increased sense of reality from their work, and therefore a tremendous incentive toward creativity. We will also have a built-in means of checking the students' work by comparing it with the activities of the professionals who are actually engaged in working out the solution for such projects.

Conclusion

Graduate study in architectural engineering will soon some to the proverbial crossroads. Unless checked, the desire of some educators to extend undergraduate study for another year or two, or to convert engineering school into a postgraduate school may be attained. We will then find that our present system of graduate education will become just another version of undergraduate study and a requirement for a professional career. Instead,

graduate study should be reserved for those men who want to go beyond the preparation for a successful professional career. These are the men who are destined to spark the progress of our profession in its many fields.

Once we realize the necessity of keeping professional graduate education apart from undergraduate education, we should start thinking about the type of teaching that we want to do in graduate school. I believe that we should give up most of the formal requirements for graduate study. Quizzes are unsuitable to test fairly a man's ability for creative work. We should develop the best constructive ability in graduate students by encouraging them to use their own initiative, and by providing them with the best background and best information possible. We can do no less to equip our graduates for a creative life.

College Notes

The **University of Hawaii** Engineering Department has completed the installation of test equipment consisting of a pair of steam-turboelectric generators. The normal rating of each turbine is 25 KUA with an overload rating of 31 KUA each. Steam conditions are 125 PSIG saturated steam at the throttle and 2 to 5 inches Hg at the exhaust. Crossover steam pressure is 50 PSIG when the turbines are operating in series. The Westinghouse Electric Corporation, the United States Navy, and a number of Honolulu industrial companies assisted the University with both material and volunteer services in installing this equipment.

The Role of the Case Method in Engineering and Business Education*

By H. BARRETT ROGERS

Chairman, Industrial Management Department, Northwestern University

The so-called Harvard "case method" was developed as a device to induce students to learn by simulating actual experiences, as distinguished from purely memorizing rules and principles.

A case is a description of real situations which must be faced by the engineer or business executive. It brings to the class room a device for placing the student into situations where, as an administrator, he must recognize existing problems, evaluate the evidence, and act with responsibility.

No predetermined answers are available to him; but through the study of a variety of specific cases involving actual company situations, the student is exposed to the types of problems he is likely to face in his later industrial experience.

With the text book method of teaching, the tendency is to memorize various terms and solutions, whereas study by the case method demands continual *use* of terms and methods of analysis to the point that they become automatic. Generalizations developed from cases do not automatically afford answers to new problems which have a way of not being "typical"; but learning how to differentiate one situation from another, and how to recognize the more important issues, contributes to the development of analytical and administrative capacity. Thus through a series of such experiences, the student absorbs a background of factual information, methods of attack, rules of procedure, and principles, for guidance in changing sets of circumstances.

Challenge and Incentive

The case method places the student into a situation where he is faced with a problem to be solved and with a course of action to be recommended. The responsibility for solutions is placed upon the student rather than upon the instructor. This challenge to the student's ingenuity is a far more potent and palatable incentive than regimented reading assignments and memorization of specific principles, formulas, and busy-work routines.

Early Frustration

During the early stages of case study, students usually grasp for some sort of "handle" to help find *the* solution, and often become frustrated when it is discovered that there may be *several* possible solutions. But the training to handle problems to which there is *no one* solution appears to be one of the main benefits of the case method. Through continual discussions in small groups, then throwing their conclusions open for class criticism, students seem to be able to develop appropriate methods of attack. Students report that progress, at first, seems slow; but upon looking back, they are surprised at the rapidity with which they have gained an understanding of the subject.

* Presented at the annual meeting, Illinois-Indiana section, ASEE, Illinois Institute of Technology, May 15, 1954.

Instructor's Role

Successful use of the "case" method apparently requires some techniques that are quite different from those used in typical *lecture* courses, and it often is difficult for a typical "lecturer" to adapt himself to this different role in the class room.

1. The instructor must be a discussion leader instead of a lecturer. He must transfer the center of attention from himself to the students, and withhold his own ideas until they, or other ideas, have been developed by the students. This is particularly difficult for the dynamic instructor with a high degree of ego.

2. He must stimulate the students to develop their own conclusions by asking pertinent questions rather than by suggesting solutions or revealing his own opinions. This places the responsibility upon the students who usually will react to the challenge of statements or proposals from other students, but who will accept, or at least not openly debate, the supposedly expert opinions of the instructor.

3. The instructor must permit and encourage a reasonable amount of free student discussion if it is related to the problem; but he must be alert to re-direct the discussion back to the problem when appropriate.

4. To force participation by, and benefit to, the greatest number of students, questions occasionally must be directed to the "quiet" student.

5. Discussions should be maintained between students, not between a student and the instructor.

6. Successful users of the case method continually emphasize a "program of action." There is a strong tendency for students to propose the first plan that comes to mind, without considering implications or alternatives. When this occurs, the instructor may well ask, "Just *how* are you going to present this plan to the workers? If they won't accept it, then what will you do?" This forces attention upon practical implementation of the proposals.

Learning to Meet New Problems

Learning by the case method is achieved through repeated analysis of varying problems, not necessarily to find solutions to specific problems which may never be repeated, but rather to develop procedures and confidence in attacking new problems. Effective learning is a gradual process, and can not be accomplished by "cramming"; thus it is virtually impossible to review for an examination in a true case type of course. However, proponents of the case method claim that no equally effective method has evolved for compelling a person to meet successively new situations on which he must grapple intellectually with fresh combinations of facts and opinions.

One of the theories of the case method is that the students learn from each other, rather than from the instructor. We might well ask, then, whether one student can learn from another if neither one has had any experience in similar or related situations and therefore knows nothing about the problem. This poses a further question, whether technical knowledge involving basically new material can be learned through the case method alone.

Could We Use the Case Method?

Our Industrial Management Department has the responsibility for Production courses at Northwestern University, both in the School of Commerce and in the Technological Institute. These include: Industrial Organization and Management, Production and Quality Control, Motion and Time Study, Development of Standard Time Data, Manufacturing Problems, Personnel Administration, Personnel Testing and Selecting, Personnel Problems, and several variations and combinations of these subjects. Traditionally we have used the technique of presenting principles and methods through reading assignments, lectures and demonstrations, with each major topic followed by a home

problem involving the application of the principles previously discussed. In our search for alternative and perhaps better methods of helping the students to learn, we visited the Harvard Graduate Business School where the case method is most extensively used. We visited particularly with Franklin E. Folts, author of the well known text, *Introduction to Industrial Management,* which deviates radically from the usual style of Industrial Management text book and is, in fact, a collection of cases in the field of Production. Mr. Folts has been instrumental in, and largely responsible for, the development of the case method as used in the Production sequence at the Harvard Graduate Business School. Our interpretations of his comments are somewhat as follows:

1. Cases are used as a vehicle for lending reality to the existence of industrial problems and the need to find workable solutions.
2. The cases are carefully selected and prepared, always keeping in mind the overall objectives which are:
   - 2.1 To provide an appreciation of the relationship of production to other operating problems of business, and an awareness of the production aspects of administrative problems.
   - 2.2 To develop familiarity with, and a degree of facility in, the use of certain procedures and techniques that have had their greatest development within the factory and that are rapidly gaining much greater significance as their applicability to other areas becomes more widely recognized; also to develop an appreciation of the limitations of such procedures.
   - 2.3 To develop a degree of self confidence and recognition of personal capabilities in technical and mechanical areas.
   - 2.4 To develop important mental characteristics such as critical perception, imagination, analytical ability, judgment, and self expression.
3. The cases are presented in a carefully planned sequence, each drawing upon knowledge and experience gained from previous cases.

   Quoting from a report prepared by Mr. Folts:

   > The early part of the subject is . . . organized in terms of techniques which are studied one after another. As soon as a technique is explored, management problems arising from the use of that technique are studied. Thus each early section of the subject deals with both technical and management considerations. As rapidly as student grasp of management concepts permits, the number of management problems in each section progressively increases. Delaying such topics as production control and manufacturing organization to (the latter part of the sequence) enables us to take advantage of the cumulative understanding of administration which the student gets from the (earlier) subjects.
   >
   > The organization of the subect can best be described by comparing it with an apprenticeship program. The new employee learns by doing —from the simple to the complex.

4. The presentation of Production material is by no means limited to student discussion of problems arising from the case.
   - 4.1 Extensive use is made of visual aids such as actual machine demonstrations, and especially prepared moving pictures.
   - 4.2 Although formal laboratory periods are not used, certain types of skills are developed by actual student participation in drills or exercises where physical facilities can be provided in the classroom. For example, even with classes which regularly contain 100 stu-

dents, each student is provided with a time study board and stop watch, and he gains some facility in making time studies by recording times for operations presented in the form of sound moving pictures.

4.3 Explanations of technical procedures frequently are made by the straight lecture method where appropriate. In fact, Mr. Folts indicated that perhaps one-third to one-half of the total class time was occupied by pictures, demonstrations, and lectures by the instructor.

From this brief discussion, it would appear that the more technical the subject in which the student has had no previous experience, the less adaptable will be the pure student-discussion type of case study, and the more will the instructor be required to present and explain basically new material.

Learning by Doing

The term "case method," which recently has acquired considerable publicity and popularity, implies "learning by doing." Intangible ideas and concepts, which can not easily be developed by physical demonstrations, are learned through the experience of personal participation in arguments and discussions. But the technique of "learning by doing" certainly is not new. Technical engineering laboratory courses are, in our opinion, live case courses in the real sense of the term. Perhaps one of the effective features of "case" courses is an increasing adaptation of the laboratory type of personal experience in subjects which, heretofore, have been considered too intangible for formal laboratory periods and physical laboratory facilities. It is to be noted that the philosophy of the case type of instruction is to induce the student to learn through personal experiences in practical problems which, for class room convenience, are closely simulated through well prepared cases.

Less Extensive but More Intensive Coverage

The case method often leaves the impatient instructor with a feeling that too much time is wasted on inconsequential discussions, and that insufficient material is being covered. But to the student who usually has much less knowledge or experience in the subject (often none whatever), such discussions may be significant and necessary steps in his grasp of the situation. At least they demonstrate that the student is alert and actively participating in the learning process, rather than merely sitting with a partially or completely closed mind while the instructor "covers a lot of ground" which no one by himself comprehends. Perhaps it is better to comprehend some material well, than to "slide over" a great deal of material without comprehension. If this proposition is accepted, then the instructor may be required critically to examine and evaluate his course outlines to assure that the truly important material will be included within the limitations of the time schedule.

Precautions

It may be in order to mention one or two precautions in the use of the case method. Inexperienced instructors often are inclined toward a too literal interpretation of undirected or free student discussion. One young instructor in a Human Relations course described some of his experiences. This instructor usually called on the first student to raise his hand in response to a question or to an argument presented by another student. It soon became evident that practically all the discussions were carried on by only a few members of the class. The other students avoided possible embarrassment by staying out of the arguments, but thereby lost the experience of active participation which the case method was supposed to encourage. One particularly eager student began to dominate the discussions. He always came to class well prepared and usually could argue down

any other students who did not agree with him. He emerged as the unofficial but nevertheless real leader of the course, with the instructor eventually becoming relegated to an unimportant role. The result was to stifle active participation by other students just as effectively as if the instructor had dominated the situation with his own opinions and preconceived solutions. Resentment grew among the other students to the point where they bitterly complained to the instructor and proposed some rather drastic actions against the overly eager student. Here was a real problem in human relations which developed unexpectedly and, by lack of appropriate early action, was permitted to grow out of control.

An older instructor with long experience in case studies later commented that the successful teacher of cases must know when it is proper to avoid completely uncontrolled student discussion, and how best to perform his function as a discussion leader by maintaining some reasonable balance of participation by members of the group.

We Believe We Can Use the Case Method

The current thinking in the Northwestern School of Commerce is toward wider use of the case method of instruction. We believe the basic philosophy is sound. Not all of us are yet convinced that completely free student discussion of problems with which they have no knowledge or experience, is the most effective way of developing or imparting technical information. At the undergraduate level, we are not yet sure that the average student has sufficient interest or maturity to seek information from outside sources in order to prepare adequately, and to project himself realistically into the completely unfamiliar role of a high level executive. We have much to learn in using the case method to the greatest advantage.

We are convinced, however, that any device is desirable that will arouse student interest and active participation, and we believe that the use of cases is one such device, perhaps one of the best yet developed. Many of us are of the opinion, however, that we already are using this device to a greater extent than would be admitted by some individuals who profess to be experts in this technique. Some persons seem to feel that a "case" requires many pages of descriptive material and must include a variety of problems and implications which may not be obvious without very thorough analysis.

What Is a Case?

It is our own opinion that a "case" presents a situation. It should require some discrimination to determine whether a problem exists, and what the problem actually is. It should challenge the student to plan a method of attack. This, in turn, should require an evaluation of available information, some decision as to what additional information, if any, may be required, and a plan for obtaining such additional information. The analysis should be followed to some logical conclusion. This conclusion should be evaluated critically to determine its acceptability and possible limitations, and a "plan of action" should be developed and evaluated for effective application. This description of a "case" and its use will be recognized as a systematic application of the "scientific method."

What Is a Problem?

In contrast to the case, a "problem" might be described as merely one phase of a case. A problem is assumed to have been already identified and actually to exist. Often it is presented without requiring any evaluation of its importance. Usually specific information is provided which the student more or less automatically substitutes into a prescribed procedure or formula, in order to "crank out" an answer which already has been predetermined by the instructor; and the student passively accepts the instructor's answer as the only correct or possible solution.

Perhaps the weaknesses in this "problem" approach are:

1. Original data are accepted by the student without question.
2. No discrimination is required to identify the problem and there is little or no evaluation of its practical importance or its relation to, or effect upon, other areas or activities.
3. The procedure or method of solution is prescribed, which the student is expected to memorize. There is no challenge to the student to develop a method of attack through his own ingenuity.
4. There is little or no evaluation of the accuracy, importance or completeness of the available information, or whether it is fact or opinion.
5. There is little or no evaluation of the reliability of the solution. The instructor's solution is accepted as the only correct or possible answer. Its applicability is unchallenged, and there is no incentive to consider limitations, alternate possibilities, or the means of application.

Can a Problem Become a Case?

It may be possible, however, to overcome most of these weaknesses, thereby turning a problem into a case, if the instructor exercises enough ingenuity in presentation. In our own courses in motion and time study, and particularly in the development of standard time data, the pass-out material would appear to the casual observer as problems rather than cases. However, each problem is introduced with a rather complete class discussion of its background, importance, and position in the Industrial Engineering function. The method of attack is developed through guided class discussion rather than by straight lecture. Practice in the use of the analytical procedure is obtained by working out the problem. On some problems, procedures are available whereby the student actually evaluates the accuracy and the applicability of his solution; and on other problems, the students' solutions are discussed in class to bring out possible implications and limitations in actual shop use.

This technique might be interpreted as a compromise between fractionalized presentations of individual topics through separate problems, and the more integrated approach through elaborate cases. If it is a compromise, we feel it is a convenient one for a technical subject. The problems have been developed for a well integrated course and are introduced in a carefully planned sequence so that each involves the use of techniques learned in previous problems. For this type of technical subject, we believe that we are achieving, in fact, about the same goals that are claimed for the "case" approach.

Grading

One of the problems in using case type courses is to find a suitable device for grading the progress of the students. Suitable quizzes are difficult to prepare. A popular type of examination is merely a written report on an additional case. Evaluation of such examinations is highly subjective and debatable.

Harvard's evaluations of student abilities are based on a novel and rather unique system. Six or eight quiz "cases" are written by each student during the school term. Each report is evaluated on an analysis sheet. Factors considered include: Selection of Facts, Use of Facts, Use of Figures, Development of a Decision, and Conclusion and Recommendations. Each of these factors is checked as Discriminating, Adequate, or Inadequate. The Presentation may be considered as Difficult to Understand, because of Handwriting, Expression, or Organization.

As these evaluation sheets accumulate, the ability of the student in any given area becomes evident. He then is interviewed by his instructor and together they attempt to re-direct the student's efforts so that the apparent weaknesses may be overcome. The success of this plan seems to be indicated by the trend from "Inadequate" to "Discriminating"

evaluations. No grades are assigned until the end of the course, and are based (apparently quite subjectively) largely on these evaluation sheets.

Report of Actual Experience

During the 1954 Fall quarter, we have used the Harvard cases, Production Volume I for our introductory production course, Industrial Management I. Approximately the first half of the quarter was devoted to blueprint reading and learning what operations can be performed on general purpose metal-working machines. Because these particular topics are somewhat uncommon in typical industrial management courses, available library references were rather inadequate in these areas. During the earlier sessions, the instructors attempted to develop the principles strictly from student discussion rather than giving any direct declaratory or factual instruction. This was a period of considerable frustration. The students had difficulty grasping this material and could not understand why a business manager should be concerned with such topics. The instructors felt that progress was discouragingly slow. To help overcome some of the difficulties, digests of certain technical material were prepared and passed out to the students, and the amount of direct instruction was increased.

During the latter part of the quarter, topics included methods improvement, time study, calculation of standard operation times, and wage incentives. Small assembly fixtures were constructed and made available to the students to use in developing improvements for their assigned problems. Stop watches were distributed for individual student use in time study practice. These physical facilities gave a much greater sense of realism. Furthermore the students were beginning to see some practical application of their knowledge of blueprints and machine operations. The general attitude changed from one of frustration to one of enthusiastic interest. One bit of evidence of this interest was a frequent comment by students that they were spending so much time on this course that they tended to neglect their other subjects.

Three different instructors were directly involved in the several sections of this course. Because the same material was being used, it seemed important that all sections should follow precisely the same schedule. Accordingly, the instructors visited each other's classes and spent a tremendous amount of time outside of class in coordinating their work. The instructors' burden proved much greater than usually is associated with a typical text-and-lecture type of course, but our present opinion is that the accomplishments are well worth this additional effort.

Need for Integration Between Fields

We have yet much to learn about the use of the case method of teaching, but we are sufficiently pleased with our results that we intend to develop its use to the best of our ability. It is our opinion, however, that the case approach in our Production courses will not reach its greatest effectiveness until a similar approach is used in the other areas such as Finance, Marketing, Statistics, Accounting, and Economics, and even then not until the courses in all these areas are closely integrated so the student can see the many inter-relationships in the composite picture of a business enterprise.

We are convinced the case method has many advantages for teaching business subjects, even those containing a considerable amount of entirely new and technical material. We believe also that, with sufficient ingenuity, a similar approach can be highly effective in many engineering subjects.

• • • YET-ITUDES*

• *yelps and helps for the young engineering teacher*

Contributed by CYET
PHIL WEINBERG, *Chairman*
University of Utah

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N. C. State College

Propagation YET

By LEE HARRISBERGER

Assistant Professor of Mechanical Engineering, North Carolina State College

The entire engineering teaching profession is dependent upon its new members for whatever progress it will achieve. The advances we must make in engineering education in the next 25 years will not be made by those who have been working hard the last 25 years—they will be made by the new teachers (the YETS) who are in our faculties right now!

The Committee on Young Engineering Teachers was appointed in 1949 to be concerned about the young teacher of engineering. The committee has appointed sub-chairmen to establish a local contact in each faculty of his section. Through these sub-chairmen and local contacts the CYET has established local groups of young teachers, organized programs for or about YETS at the section meetings and assisted the Society in its membership drives. On the national level the Committee has sponsored several excellent meetings at each national convention for young teachers. Since 1952 a National Paper contest has been established to encourage the young teacher to submit his ideas on improving engineering education. A great deal is left to be done for, about, and because of the young engineering teacher.

The industrial demand for graduates is at an all time high and will far exceed the supply for years to come. This particular demand for engineers today has attracted YETS to industry in droves. At the same time the suction of high industrial pay has cut heavily into the graduate school enrollment, the teaching profession's main source for YETS.

At the present time our undergraduate enrollment is low and the demand for new teachers is not great. This is fortunate since there are virtually no young men seeking engineering teaching jobs. Within a decade a tidal wave of war babies will be nearing our colleges and the enrollment will be doubled. The excellent publicity campaign by industry in the past three years has greatly increased this year's freshman and sophomore enrollments. Next year our engineering colleges will be hit with larger junior classes—the scramble will be on

* "YET-itudes" is devoted to informing the Society of the needs, pleads, and deeds of the young engineering teacher. The potential of ASEE lies with the young engineering teacher. The CYET feels you should be informed of how much "fire is in the furnace."

YET-itudes! Not Platitudes!

for new staff members—and there will be few to find. What are we doing to ensure that we will have adequate staff to handle this certain-to-come increase?

The time is about here when ways and means of recruiting young men into graduate work and engineering teaching must be found. We are faced with a real problem—we want to encourage our top seniors into this group. What can we offer?

For the student's immediate interest, we can offer him an assistantship or fellowship to go to graduate school (which hardly pays for his tuition and books and rarely covers his living expenses). We offer him 1–3 years of backbreaking studies and part-time teaching. We offer him an M.S. degree and hire him at the rank of instructor at a salary, in most cases, less than the salary he could have started with in industry with his B.S degree.

This is a tough row to hoe for the teaching profession. Perhaps we should persuade industry to help us perpetuate our race. Could we suggest that when an industry interviews our capable students, they select one or more of the students we suspect might make a fine teacher and sponsor him through graduate school at the same salary they would have hired him for? Industry admits that a graduate's first two years with them is mostly unproductive apprenticeship. Could we also suggest that upon his graduation, the sponsoring company let the man hire into an engineering faculty as a full time staff member and spend his summers doing research and engineering for them where feasible?

Industry can't function without the engineering talent we produce. We in engineering education can't produce this talent if industry attracts capable young men away from graduate work and teaching. The CYET is concerned about YETS—but it is equally concerned about having YETS to be concerned about.

Here is a YET-itude which cannot remain merely an attitude platitude.

The Engineering Graduate in Automotive Industry Today and Tomorrow*

By R. D. AMBERSON

Director of Personnel Activities, Chevrolet Engineering Department, General Motors Corp.

The engineer in the automotive industry today is no longer simply an engineer, whether or not he himself recognizes it. By the time his duties give him a right to the title of engineer, whether it be design engineer, project engineer or staff engineer, he has become an engineer-executive. Our aim today is to develop men effectively for their jobs and the jobs they will hold tomorrow. To do this we must be concerned not only with their technical competence, but also with their social adjustment and facility of expression. These last two are basic skills the engineer needs to be a successful administrator.

Today, industry values the ability to work harmoniously with others as highly as it does the technical competence of the average graduate engineer. Technical competence without social skills is insufficient. Friction can ruin a smooth running organization just as quickly as it can a well designed piece of machinery.

For this reason, Webster's definition of an engineer "one who is capable of designing" is no longer sufficient. Each new duty of the engineer has added a qualifier to the definition until Chevrolet can accept only this as adequate: "An engineer is one who is qualified by education, experience and ability, to direct the operations of personnel and facilities in the execution of assigned projects."

Quite a mouthful, but it must be, to encompass the usual duties of the average automotive engineer throughout his career.

To understand why we are so particularly concerned with these features of an engineer's duties you should know something about the organization of Chevrolet Engineering, and our method of dividing the engineering responsibilities.

The personnel of the Chevrolet Engineering Department now numbers about 1800. They are assigned to five functional groups, each of which is under the direction of an Assistant Chief Engineer. These groups are:

Research & Development Engineering
Design Engineering
Test Engineering
Production Engineering
Administration

The Research & Development Engineering group conducts studies and experiments leading to the development of new and advance vehicle designs to the point where they may be turned over to production design. The group is divided along natural lines between Passenger Cars and Trucks under the guidance of Staff Engineers.

Design Engineering is divided into four groups:

Passenger Car Chassis
Truck Chassis
Passenger Car Body
Truck Body

* Presented before the Cooperative Engineering Education Division of ASEE, University of Illinois, June 15, 1954.

Each is headed by a Staff Engineer who is responsible for the production design of the various components.

Test Engineering is conducted by two groups doing Technical testing at the Test Laboratory and Road Testing at the General Motors Proving Ground. These operations are assigned to a Staff Engineer.

The Production Engineering department has a number of men placed at the major plants who are known as Resident Engineers. It is their responsibility to maintain close contact between design engineering and the manufacturing organization so that the designs of all parts are suitable for Chevrolet's high volume production.

It is into this organization that we introduce graduate engineers and start them on our Training Program. In a two-year period we try to give the trainees a well rounded picture of our organization and its functions. This we accomplish by routing the trainees through varying assignments for periods of three months each, under the supervision of our Resident Engineers.

The Administration section provides operating facilities for the common use of the department as a whole, such as drafting, records and specifications, experimental fabrication and assembly, and interdepartmental liaison. It is also responsible for the interpretation and execution of the Corporation policies within the Engineering Department.

This entire staff reports to our Executive Assistant Chief Engineer.

This gives you some idea of the scope of administrative responsibility of the Chief Engineer and his assistants. While only about a sixth of these 1800 people are engineers, all of them are under the supervision of engineers.

Fail to Prepare for Broader Duties

Gradual extension of the engineer's influence and the multiplication of his duties has not yet, I think, struck the consciousness of the average undergraduate. He still seems to think in terms of a design job or a research project or some other short range objective, and consequently he often fails to prepare for broader duties he will inherit with the promotions he so intensely desires.

A recent survey by the National Society of Professional Engineers gives startling proof of the prevalence of this aspect of engineering. It concludes, "The complexities of modern industrial processes have tended to put more and more engineers into office jobs. Fifty-four per cent of the participating engineers work at desk jobs." 54%, think of that! That does not mean at a board or at a bench but at a desk job with administrative functions.

Another phase of engineering which may have escaped the notice of the average student is the fact that engineering has for some time been a coordinated activity. There are few positions anymore where the engineer can operate in seclusion. The majority of his assignments will be as a member of a group or a team, who contribute cooperatively to the solution of a product problem.

In industry as it is today, an engineer cannot do the whole job alone. For example, the engineer given the assignment of matching the chassis components for a comfortable riding automobile must depend upon the efforts of many other engineers. He must have the experience of the mechanical engineer to assist in the design of the chassis. He must call upon the metallurgical engineer when he is determining the type of spring material to be used. He must call upon another engineer who specializes in hydraulics when he is selecting a shock absorber. He also needs the services of the electrical engineer when working with the electronic instrumentation and when using strain gauges and oscilloscopes. In addition to all these, he must work closely with those engineers responsible for manufacturing and production activities. As you can see, the activities of people are just as highly integrated as production techniques.

Now, how are the engineers who are manning this organization measuring up to what industry expects of them? Evaluating their technical background, we would say "very well." Especially, those who have participated in a cooperative program while they were in college. We employ quite a few of these people at the present time. To be exact we have in our organization 62 graduates who had cooperative experience and we now have 38 people who are presently in the cooperative program. We have had ample opportunity to observe their performance and have seen that by the time they graduate, they are well acclimated to the industrial picture.

Of course we all know that education is much the same as heat treating. You must have something basically good to start with. You could heat treat a piece of 1010 metal from now on and fail to come up with the desired degree of hardness because the "stuff" was not there to start with.

The same applies to some graduates, very few, thank goodness, in engineering.

We also employ engineers who have graduated from the traditional four year course and have had no previous industrial experience. Let us compare the performance of both types of graduate.

We in Chevrolet feel that the cooperative student has the advantage over the solely academic graduate for the first ten years of his career. These are the reasons.

The cooperative student has had an opportunity to see the work that has to be done and to actually try many project assignments. Consequently, he is more likely to know what engineering work actually entails and to discover for himself what activity best suits his talents and tastes. He is, in short, less likely to leave a placement interviewer with the feeling that he believes there are only two major assemblies in an automobile—the engine and what goes with it. He is also aware that in an organization like Chevrolet, trucks are just as important as passenger cars in our overall effort.

In 1953, Chevrolet produced 343,000 trucks. More trucks than the entire individual output of two other G.M. car divisions. So trucks cannot be overlooked from an engineering standpoint.

Students other than cooperative with less experience in the actual work of engineering too often orient themselves towards the glamorized aspects of the field. Internal combustion engines for instance. They do not appear to appreciate the fact that the other major components—transmission, chassis, the suspension—are just as important as the engine. We cannot blame them for perhaps they have never looked at these other important features in the same light as they have seen the engine. We can be thankful that some of the sports car magazines, which sometimes come into the hands of engineers and students, also have made a point of emphasizing the effect that the design of the suspension has on the performance of these fast stepping cars.

Industrial experience sometimes tends to de-emphasize the importance of a diploma in the graduate's mind. He comes to the realization that it is what he has learned, not the proof of having spent years in school, that really counts. He will see that he has to take his place along side and compete with men who have just as much education as he has. His most sobering experience of all is, I think, meeting men who have never gone to college and who are very competent engineers. These are men who always possessed engineering talent but through lack of opportunity or the pressure of family responsibility have never had the privilege of attending college.

Opportunity to Learn and Grow

It is they who have accepted wholeheartedly what industry tries to offer every man, college graduate or not; that is, the opportunity for him to learn and to grow. These things the cooperative student has learned.

The cooperative student, after he has become acquainted with the work of engineering and has his feet on the ground, is more likely to have formed a definite opinion of where he is best suited and is better able to concentrate his effort toward that area in the field. In that he has selected a career objective, he has achieved a large advantage over the 4-year student, who at graduation has usually only a nebulous idea about his career objectives.

We have come to know that a cooperative system in a college is only as good as the coordinator, which is only another way of saying that you, as coordinators, are the keys to the whole situation. Our experience with one school, which I will not name, was bad. The coordinator seemed interested only in getting the student so[illegible] kind of a job. Whether or not it related to what the boy was studying seemed to be secondary. After placing the student, he wanted no information as to his work record and declined to give out information to the employer regarding the boy's schooling.

In other words, the coordinator wasn't coordinating. This, happily, is the exception rather than the rule.

The attitude of most cooperative students is a pleasant contrast to the growing reluctance on the part of many graduates to accept work assignments which will give them the foundation and the experience they need to progress. Nowhere is this reluctance more visible than in the average graduate's attitude toward drafting room assignments. They look upon it with about as much relish as they would "the black hole of Calcutta." At the same time, none would refuse the opportunity to become a designer. You gentlemen realize, of course, that this is tantamount to a student requesting admission to a class in differential equations when he has no more than a superficial acquaintance with algebra.

You hear from the students that they don't want to get "stuck on the board" and yet it's the man with the sharp pencil who comes up with the design ideas and is preparing himself for an executive job in engineering. An executive without good board experience can be fooled by and good draftsman.

Think of Leonardo da Vinci, Thomas A. Edison or Michael Angelo. Those men were not above long hours on the board and in the laboratory and the results are known by all.

Drafting skill and experience are undeniable prerequisites to a successful career as a designer. As for the matter of opportunity, I don't know where students get their impression that there is any lack of it in the drafting room. The fact of the matter is that disinterest in drafting has created an unusual opportunity. Overconcentration of interest in testing, engine development and other phases of engineering has made them overcrowded and thus reduced, percentage-wise, the opportunities available through those avenues. The drafting room, on the other hand, has too few candidates for the positions which are available.

This presently creates an extraordinary opportunity for the gradute who is willing to be guided by his aptitudes, not his prejudices.

While colleges are turning out technically skilled engineers, many of them are unfortunately neglecting the development of executive potential.

The same survey I mentioned earlier, conducted by the National Society of Professional Engineers, reports that "sixty-two per cent of the employer group contacted felt that their engineer employees were inadequately prepared in college to meet the tasks which lay ahead of them in industry and, with this, twenty-eight per cent of the engineers themselves agreed."

The survey analysts further stated that "It was made quite clear that something should be done, and quickly, about the curriculum of many of our engineering schools . . . that engineers should be re-

quired to carry more English, and social studies and the 'humanities' . . . that, in short, those schools which have narrowed their curriculum to exclude or dismiss with a modicum of attention, nearly everything, apart from purely vocational work, had better start turning out more, not merely engineers, but educated engineers."

You can infer from this last statement that the dissatisfaction with the present engineering graduate is not because of his technical competence but because he lacks social skills and poise which are prerequisites to the more responsible positions in engineering.

These skills are not simply "icing on the cake." Industry, as you know, is not interested in the "polished" man for his own sake. These skills are in reality valuable tools which will enable him to perform his intended function. An insight into the gravity of the matter was given by a man in our group who was discussing the engineer's impatience at his lack of advancement.

He summed it up in this fashion, "Too frequently graduates are unable to realize that the next job ahead, while perhaps within the reach of their technical abilities, often requires, as well, abilities of another type—such as those required to direct and supervise others, to sell their ideas and plans—which they have not sufficiently demonstrated."

Invaluable Engineering Tools

Clear expression and persuasiveness are admittedly skills of rhetoric but they cannot be sloughed off with that admission. They are invaluable engineering tools. A short while ago, our Assistant Chief Engineer in charge of Administration called together all our engineers and reviewed the nature of their duties and responsibilities. He reminded the executives in charge of project assignments that "From his vantage point in the organization, the executive should know more about the overall situation than the operating engineers. He should make use of that knowledge in planning the execution of the project. But all the knowledge he may have and all the planning he may do is of little benefit until it has been clearly conveyed to the man who is responsible for getting the job done."

These skills must be displayed at lower levels too. "When the design has progressed to the proper point, it is the Project Engineer's responsibility to secure the necessary approvals. Here again he has the opportunity to show his true stature. If he makes a strong intelligent presentation, answering questions in a straightforward manner, he proves himself to be master of the situation. As such, he is merely giving a preview of how he is likely to operate on a higher level in handling broader assignments."

Equipping the engineer with these necessary social skills is the mutual concern of both industry and the educators. We at General Motors have made a beginning by providing our employees with opportunities to broaden themselves. The most popular and long-standing of these is our sponsorship of the Dale Carnegie course to develop effective expression—one of the primary tools of the engineer-executive. At this time, a large proportion of our men have participated in this course; and employee demand for the course continues.

We are planning now to exert even greater efforts through an Organizational Development Plan which was presented under the title "Safeguarding Our Assets," our greatest asset being good manpower. The object of this program is to develop our men along the lines we have just sketched. We have expended a considerable amount of time and effort to create an opportunity for the graduate to acquire the skills he needs for a successful career in engineering as it exists today.

At best we can only produce a patched-up job. We almost come to a point where it is easier to redesign than to modify any further. The best way to get the graduate industry wants is to start the fresh-

man on a program designed for modern requirements.

We feel that perhaps the solution to this problem will be in the path blazed by cooperative education, using a program to improve the social adjustment and facility of expression of the engineer, formulated by the colleges and carried out with the assistance and cooperation of industry.

Whatever the method; whether it be classroom work in Engineer's English, Social Sciences and the Humanities, as the survey suggested; more emphasis on group activity in academic work; or day-to-day insistence by the instructor that the student practice these skills; we have to cultivate them in order to prepare the engineer for his expanded duties of today and tomorrow.

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The Individual Manufacturing Operation—A Component of the Manufacturing Process*

By J. F. CLEARY

Instructor of Industrial Engineering, Case Institute of Technology

Within the framework of our theme, "The Function of the Industrial Engineer in Processing," I have been asked to discuss the relationship of the Industrial Engineer to the Manufacturing Processing Area and what can be done to raise the instructional level in this area. Before approaching the subject of how to present a more meaningful course coverage in Manufacturing Processing to the Industrial Engineering Undergraduate, I think it is necessary to review the premise upon which the suggestion is based. The function of the Industrial Engineer is gradually emerging from a quasi-managerial relationship to that of a clear-cut design function—the design of the manufacturing process. Upon the Industrial Engineer is being placed the responsibility of selecting the optimum operations for the work to be done, designing the tools that are required for the adaptation of the work to the equipment in question, and designing the pattern of motions used by the operator in performing the work. Finally, he is expected to integrate all the operations into a process that will produce the quantity of parts required to the quality specified, in the time required, for the least cost.

The objective of this design is twofold in nature:

(1) To optimize the probability of satisfying the consumer with respect to cost, quality, and the availability of the product.

(2) To insure the expected return on the stockholder's investment.

If this is an adequate criterion for the design of the process, then there is a serious question mark on the validity of our present approach towards one of the building blocks of the process—the individual manufacturing operation. It is not sufficient that the Industrial Engineer be able to analyze any particular operation for the purpose of developing an improved method, he must be able to survey all the existing operations capable of producing the part in question and to select the optimum operation.

Each part that is to be manufactured is a different problem. Each must be considered for the quantity required, the critical dimensions specified and for the delivery date indicated. A number of factors must be considered in each case:

(1) Should the raw material be brought into the process as some form of mill stock, a forging, or a casting?

(2) How can the total work required for converting the raw material to the finished part be subdivided into operations?

(3) Which of the alternative manufacturing operations are adapted to the type of work required?

(4) Are the natural dimensional variabilities of the suitable operations compatible with the design tolerances?

(5) Is it desirable, or necessary, to supply work and tool holding de-

* Presented before the Industrial Engineering Division, ASEE, at the University of Illinois, June, 1954.

vices for the operations under consideration?

(6) What is the nature of the procurement time for raw material and the tooling that is required?

These are typical of the factors, concerning the alternatives, that must be considered before the engineer is prepared to establish the process.

Anything But Static

The preparation of the Industrial Engineer for this design function could be started in the early Manufacturing Processes courses. I do not feel that learning the manipulation of the basic machinery and the associated terminology is sufficient. The status of the manufacturing operations is anything but static, new operations are in a continual state of development. It is, in fact, the engineer himself who is expected to do much of this development. The engineer must be armed, not only with a knowledge of the basic mechanics of the various classes of operations, but also, with the principles that determine when the operation is a competing alternative. While each of the classes of operations, such as metal-cutting, casting, forging, and etc. are governed by different fundamental principles, all the classes of operations are similar in that they are alternatives towards the objective of satisfying the consumer's product needs.

It may be that the consumer is not directly concerned whether the engineer uses a forging or a casting on a particular component of a product. He may not be interested in the fact that a gear is a precision casting, rather than a conventionally hobbed gear; but he is interested, to some degree, in the cost of the product, its availability for purchase and how long it will last in service. It is through these factors, and others, that the choice of the manufacturing alternatives may have a part to play in his decision to buy.

In developing the Manufacturing Processing courses to suit the Industrial Engineer's design requirements, the underlying principles of the different classes of operations must be emphasized to a greater extent. The design objective requires the ability to predict the outcome of the operation. This depends upon a more complete knowledge of the mechanics of the operations, rather than the ability to operate the equipment involved. The objectives of the Manufacturing Process work must be shifted from the development of manual skills to the study and application of the operation principles that are the foundation of the future design work.

There seems to be no good reason why the elementary courses cannot be approached from the current point of view, a course covering each of the basic classes. It does seem necessary, in each of the courses, to focus upon the philosophy that not only does each operation enter into competition with other members of its own class, but it may also, have to compete with operations of the other classes.

The elementary courses in Manufacturing Processes should develop two groups of principles:

(1) The principles governing the mechanics of the class of operation. For example, in the metal-cutting operations, the student should become familiar with current concepts concerning the mechanics of chip production. He should be able to estimate the power required by any of the metal-cutting operations. With the power available known, and a given tool life expected, the student should be able to specify the cutting conditions for most of the metal-cutting operations.

(2) The nature of the machinery in performing the basic operation. For example, the operation of turning a single diameter on a shaft can be accomplished by the use of a number of different types of lathes. The economic advantage of one of the machines over the rest, to a great extent, depends upon the number of pieces produced per set-up. If the shaft has several concentric diameters,

the relationship is somewhat different because certain types of the lathes are better adapted for the production of multiple diameter work. If the operation is a combination of external and internal turning, some of the types of machinery are all but useless. The student should be able to determine if the combined operation is more effective than the subdivision into two or more operations. This, again, will depend to a great extent on the number of pieces produced per set-up.

Exercise Projects

The supporting laboratory exercises could fall into three groups.

(1) A group of simple exercises where the objective would be to verify the operation principles, such as the effect of cutting speed, or material properties on the tool life.

(2) A group of simple exercises for which the objective is to compare the relative merits of the different machinery in producing a part. An example of this type of exercise would be the production of the simple shaft previously mentioned. The actual exercise could be conducted by a number of students, each making the shaft on a different machine, such as a turret lathe, an engine lathe, a duplicating lathe, an automatic lathe, and others if available. The laboratory report would be the joint effort of the students involved and would compare the different methods of producing the shaft for cost, dimensional and surface quality, and total production time. Other factors that could be examined in the report would be the effect on the relative merits of the alternatives of changing the lot size, of changing the type of raw material.

(3) A group of simple exercises where the objective is to demonstrate the method of determining the nature of the dimensional variability of the operations. This group of exercises would serve to demonstrate the relationship of the variability of the operation to the design tolerances.

The exercise projects could be selected such that they are applicable to more than one of the classes of operations. For example, if one of the exercises is the production of a gear, the gear could be designed such that it could be produced by machining, as well as, a punch press operation, or as a precision casting. In this manner, a greater degree of integration could be established across the Manufacturing Processes courses.

Besides the usual prerequisites, Physics, Metallurgy, Mathematics, and etc., it is felt that an elementary course in Statistical Methods would be very desirable for the successful study of the Manufacturing Processes. A large part of the problem in this area consists of estimation and determination of the superiority of one alternative over another. Both of these computations require the consideration of the variability of the data involved.

In conclusion may I say, I think it is necessary to make the courses in Manufacturing Processing of a more quantitative nature. This can be done by considering this as preparatory work for the design requirement of the course work in Production Engineering that is to follow.

Place of the Undergraduate Thesis in Engineering Education

By R. L. SANKS

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Introduction

Within the last decade, relatively little attention has been given to the subject of the undergraduate, or senior, thesis. During the same period, research, both industrial and academic has shown a steady growth and now constitutes one of the most important phases of engineering from the standpoint of manpower demands. Only a small minority of engineering students continue their training in graduate work, and therefore the only extensive contact with research that most graduate engineers will have experienced is with the senior thesis. It seems appropriate at this time to examine the thesis requirements to determine whether it is worthwhile and whether it is a necessary part of the undergraduate curriculum.

General Considerations

To determine the desirability and the place of the thesis in the undergraduate curriculum it is first necessary to state what we wish that curriculum to accomplish. It seems to the writer that its aims should be:

1. To develop initiative and resourcefulness in the student.
2. To teach the student to reason—to think—to use his head.
3. To train the student in independence —to learn without help—to work alone—to profit by his experiences.
4. To gain technical competence and understanding of theoretical and applied mechanics.
5. To impart a reasonable amount of technical information.

We try to accomplish these by lectures, laboratories, seminars, and infrequently by requiring a thesis. Whatever may be the advantages of the lecture, laboratory, and seminar (and even their most important advantages are somewhat questionable) it must be admitted that the students are carefully supervised, their study entirely prescribed, that the instructor is readily available to explain difficult subject matter, and that the "smart" student can get by with comparatively little effort by making use of his friends' industry. As a result, little initiative or creative thinking is required. The student need only read the required pages and work the required problems in the prescribed manner. And if he is confused, he need not reason out his difficulties; either his friends or his instructors will save him the trouble. Initiative, independence, and reasoning are not developed nor encouraged, although technology may be well covered by the ordinary curriculum.

Actually it would be possible to train the students' reasoning ability and independence in lecture courses, but it is impractical because: students vary so greatly in rate of comprehension that progress would be very slow; there seems to be an uncontrollable desire on the part of nearly all instructors (the writer included) to substitute volume for quality; and finally very, very few instructors are *able* to so train students. However, if handled even reasonably well, the thesis—or other difficult, comprehensive, nonsupervised laboratory course, which can be the equivalent of the thesis—will train students to depend on their own resources,

to reason, and to work alone. The process is analogous to throwing a small boy into deep water. The student learns these things because he must.

Advantages and Disadvantages

Some of our finest institutions have retained the thesis requirement, because the faculty recognized the advantages. For example, at Renselaer the thesis requirement was dropped during wartime but reinstated soon after. Hunter [1] of Renselaer stated that the thesis is desirable because:

1. It synthesizes material studied in numerous courses.
2. It bridges the gap between college and practice.
3. It provides the stimulus for average students to do superior work.
4. There is enough effort required of each student for instructors to judge his capabilities.
5. The thesis acts as a final test of his interest.
6. It brings students into closer contact with instructors.
7. It forces him to plan his work.
8. It forces him to use all the facilities of the college and frequently to use those of industry.
9. It gives him practice in the preparation of the formal report.

Michaels [2] stated that the undergraduate thesis requirements in Chemical Engineering at M.I.T. were dropped during World War II but reinstated in order to give the student an opportunity to:

1. Make decisions on a problem of some significance.
2. Gain experience in seeking information.
3. Discipline himself in budgeting time and facilities.
4. Integrate study with prior experience.
5. Gain experience in writing a formal report.
6. Meet the staff on a professional level.
7. Develop creative talents.

To codify the advantages according to their importance, the writer would list them as follows:

1. It requires the exercise of initiative and resourcefulness.
2. It trains the student to reason and to work alone.
3. It provides his only opportunity to select, plan, execute, and report on a problem of his own choosing in a field of his major interest.
4. It provides an opportunity to survey thoroughly a limited field of literature.
5. It furnishes a small host of minor advantages such as:
   a. Correlation and integration of student's career.
   b. Appreciation of research and research methods.
   c. The starting point, sometimes, of a student's life work.

Of course there are disadvantages too, and they should be carefully examined.

1. The thesis requires an inordinate amount of time for the few credit hours nominally assigned.
2. There is comparatively little gain in technical proficiency for the large expenditure of student time.
3. Much time is required of instructors, particularly during the editing of the manuscript.
4. The wide variation in difficulty of problem and instructor's requirements makes the thesis unfair to some and too easy for others. This leads to a general lowering of standards and encouragement of poor theses.
5. It is difficult to select or advise problems within student's capabilities compatible with credit hours and of

[1] Hunter, M. A., The Senior Thesis in the Undergraduate Curr., J. Eng. Educ. 37: 453–486, 1946–7.

[2] Michaels, A. S., The Undergraduate Thesis in Chemical Engineering at M.I.T., J. Eng. Educ. 43: 90–94, 1952–3.

difficulties equal to or comparable with problems in other areas of engineering.

Most of the above disadvantages are those of inconvenience to the staff, the students, or both, and the writer fears that those departments that have dropped the thesis requirements have done so largely because of inconvenience to the staff. Certainly we should be more concerned with education than with a misguided sense of "fair play" for the student or inconvenience for the instructor. Some of the disadvantages can be overcome by proper administration.

Administration

Ideally, the key thought should be as little interference, as little direction, as possible consistent with reasonable progress. However, the student must be supervised to the extent that he becomes indoctrinated with the research method and with enthusiasm for research. He must not be allowed to make so many mistakes that he flounders helplessly and eventually, hopelessly. Practically, then, some supervision is desirable; but never to the extent that it robs the student of his one chance to use his own initiative.

During the first quarter, the student should receive some guidance in the selection of a suitable problem, in the use of the library, and in the planning of the thesis. He needs a certain amount of pushing to overcome his inertia. During the other quarters, the student should meet regularly with his advisor. An excellent way to maintain supervision unobtrusively is for the advisor to hold weekly seminars for all his thesis students. Each student can then report his progress, which keeps his feet from dragging, brings the advisor up to date, and creates a stimulating atmosphere of lively interest in research. Handled correctly, the students become the critics and the advisor usually need act only as referee. This permits the advisor to keep the whip in his hand without seeming to do so.

It was stated that one of the objections to the thesis was inconsistency of instructor's requirements. This is most marked in the preparation of the manuscript. One of the best arrangements to promote uniformly good theses is found at Iowa State College. There, format and arrangement, references and bibliography, title page, table of contents, sample figures, sample pages, and typing are carefully checked by the permanent library staff. The standards are the same for all departments. This practice results in nearly uniform high quality thesis manuscripts. Other schools would do well to emulate this example.

Another common defect of the thesis is the amount of work required per credit hour. Certainly it seems unrealistic to require any considerable original effort of a student during the time he is carrying a 17-hour credit load of other subjects. Since the thesis trains students in the most important and desirable of accomplishments, the sensible curriculum would allow enough credit hours for the thesis so that excessive interference from other courses is avoided. During the first quarter, while the student is selecting his topic, one credit hour is probably justified, but during the two successive quarters at least three and perhaps even four credit hours should be assigned to the thesis. (For schools on the semester system, 2 and 3 credit hours for the first and second semesters respectively should be assigned.)

Types of Theses

The type of thesis has considerable bearing on the value the student receives from it. The library thesis—an extensive search, evaluation, and conclusions drawn solely from study of the literature—is advantageous in that a great deal of information may be gained in a short time. On the other hand, the undergraduate is not usually well-equipped to evaluate the worth and importance of a technical paper. The library thesis requires somewhat less planning and considerably less initiative than other types.

The design thesis is appealing to many, perhaps because of the magic of the word "design," or perhaps because there is a definite goal within easy sight of the ordinary student. Although it might seem at first thought to be a desirable type, there are several serious practical defects: an impressive thesis can be compiled with little work and no acquisition of new knowledge; there is frequently a lack of challenge to best efforts; and most important, the technical training of practical design considerations and procedure is usually lacking entirely, since the textbooks do not consider them and the instructor cannot give the time necessary to teach them. Practical design is best left for industrial experience; in fact it must be because it requires several years experience for even outstanding students to become proficient designers.

The experimental thesis may consist of laboratory experiments, field experiments or surveys, or theoretical explorations of some phenomenon, supported by investigation of the literature. Such theses involve extensive planning, interpretation of results, and correlation of findings to theories. It represents the closest approach to the work of the consulting engineer. More than any other type it provides the greatest challenge to clear thinking, initiative, and resourcefulness. Its only drawbacks are that it may be time-consuming and there is not always the assurance of ultimate success. Of course, an unsuccessful thesis that has taxed the student to the utmost— that has developed in him the qualities we wish to teach—is of more value than the successful thesis of ordinary difficulty.

Summary and Conclusions

The foregoing is an attempt to evaluate, as objectively as possible, the advantages and disadvantages of the requirement of the senior thesis. Assuming reasonably good administration, the disadvantages are those largely of inconvenience to the staff —an inadmissible excuse. On the other hand, the advantages include training and development in important disciplines that are inadequately touched by other formal courses. The advantages are, therefore, so overwhelming that it might well be said that the faculty that does not require the senior thesis or its academic equivalent is shortchanging the student.

The Engineer as an Expert Witness*

By S. S. AIDLIN, P.E.

There are occasions when an engineer is called into court to testify as an expert witness relative to a phase of engineering with which he is quite familiar. Frequently, the engineer educator is the man who is called upon because of his knowledge and/or reputation.

Generally, the occasion is one involving a law suit with considerable sums of money in the balance and the legal decision largely dependent upon the information furnished by the professional engineer.

Who May Testify as an Expert Witness

Others who are not duly licensed professional engineers may possibly be brought into the picture to serve as expert witnesses relative to specific issues. But recent court rulings have apparently given greater credence to the testimony of the professional engineer just as the license of the medical doctor carries greater weight in issues involving medical questions. This is based on the recognized principle that the licensed practitioner is bound not only by well-formulated Canons of Ethics, but by an extensive examination of his ability in the art and practice of his profession. Thus he is qualified on two counts, his ability and his moral standards. In addition there is the implied understanding that his professional conduct is subject to review by the same licensing board that granted the license and that it may be revoked in cases where his conduct is detrimental to the profession or otherwise unworthy of the license.

The author of this article has appeared in court a number of times as an expert witness and the following comments and observations are largely based on personal findings and considerations.

Qualifications of an Expert Witness

When the professional engineer does appear in court, his qualifications are usually not challenged by the opposition.

However it is wise to state one's qualifications in order to impress the court and jury. Qualifications are sometimes challenged on the following grounds:

A. If one is a specialist, his field may be too narrow to encompass the immediate issue.

B. If one is not a specialist, his field is too broad to know enough about the specific issue.

C. If one is old, he may not be conversant with the latest developments and advances in the profession.

D. If one is young, he may lack adequate experience to qualify.

Method of Testifying

It seems best, therefore, to present one's knowledge in the subject. Generally speaking, a witness can be cross-examined only on what has come upon direct examination. Therefore, it is advisable to adhere to simple facts, stated in generally understood terms rather than in highly technical language. The latter may be misunderstood, or worse, its

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* From *Professional Engineering—Economics and Practice*, originally published in 1952, by Pelex Publishers, Inc., New York, N. Y.

Mr. Aidlin is a consulting engineer with offices in New York City and is on the teaching staff of two leading Engineering Institutions.

meaning may be distorted by the opposition.

To give a specific example, in a recent court case wherein the author was testifying, the question was whether there was attempted fraud on the part of a contractor in selling and installing a central heating furnace and boiler which were inadequate for the building where installed. A heat balance was made and it developed that a vendor's proposal (which became part of the subsequent contract) was for a properly rated boiler. However, the unit installed bore no name plate data nor any recognizable professional rating. Tests indicated that the unit could not get up enough steam to provide adequate radiation for comfort heating and the contractor contended that the piping was at fault (which was not included in the contract).

In another instance there was a contention raised that a device used on amusement vehicles such as roller coasters for holding passengers in the compartments infringed on another patented device for automatic locking of compartments. The author of this article was called as an expert witness by the defendant and was able to show that the roller coaster locking mechanism functioned on the same principle as ordinary toggle clamps in general use in machine shops everywhere, except that the actuation of the clamping mechanism was controlled from outside the compartment. Thus, by presenting the explanation on the basis of common experience, it was possible to show the lay jury that there was no infringement in this case.

In the presentation of the engineering witness's findings, he did not refer to equivalent square feet of radiation, BTU's heat transfer coefficients, etc. Instead, it was pointed out in simple language that the boiler lacked adequate volume for proper firing of the required oil for suitable heating of the premises, that the boiler surfaces exposed to the heat of the fire were inadequate for development of the required amount of steam. The evidence offered was personal observation and opinion basd upon previous experience, comparison with accepted well known rated boilers and recognized trade and professional standards. (The verdict handed down was as we expected.)

Frequently, the opposition will attempt to trip up the professional engineer testifying by attempting to lead him into an argument. The witness should adhere to the facts without losing control of the situation by arguing. The lawyers generally win out in such instances.

In addition, when asked if the engineer has made a complete examination or analysis there is an attempt made to confuse the witness because a complete investigation is virtually impossible. Instead, a proper answer should be that the investigated was as extensive as warranted.

Printed Matter as Evidence

Inasmuch as writings, as such, are not subject to cross-examination, they are generally not admissible as evidence.

However, such material may be considered as corroborative evidence and may be introduced in such a manner. But it may be introduced by the opposition in an effort to becloud the issue or to cast doubt on the evidence of the engineer. Before doing so, the opposition may introduce the writing and ask if the witness (the engineer) considers the author of the writing as an authority. There are several possible answers that may be offered by the witness:

1. May not consider the author an authority.

2. May explain that the writings are out of date and that the beliefs or opinions outlined therein are superseded by more advanced ideas in the profession.

3. May consider the author an authority in certain respects only. This prepares an opening in the event of a subsequent disagreement between the author and the witness.

In any event, it is wise for the witness to prepare himself with reliable writings

by others or his own which have been sponsored by or published by recognized authoritative groups such as professional or engineering societies. However, it is best not to cite these writings until the opposition has introduced others, because this affords an opportunity to refute contrary opinion.

Fees Charged by Expert Witness

In the matter of fees, the opposition will attempt to influence the jury and to cast doubt upon the evidence of the witness on the basis of personal interest in the outcome of the case. Accordingly it is unwise and, in fact, unethical to accept a fee contingent upon the outcome of a case.

It is generally advisable to charge on a time basis depending on the amount of time involved. This usually includes an allowance for travelling time to and from the court. It is well to bear in mind that the fee basis should be made in advance to those who will be expected to pay the bill, and agreed to by them. However, in some instances, because of excessive or intolerable demands, the expert witness has been subpoenaed to testify without fee.

Subsequent Courtroom Action

In connection with the above, it is recommended that the witness leave the courtroom as soon as he has presented testimony. He should not wait around lest he be considered an interested party in the case, and lest he be discredited for having no practice to occupy his time. However, by leaving directly, the jury will consider that the witness is willing to stand on his testimony. By the same token, one should not read or whisper in court, but should comport himself in a dignified manner so as to reflect dignity upon himself and upon the court.

Another bit of advice: The witness should not assume he knows it all nor give that impression. The opposition is probably prepared to a large extent and may, in fact, have been briefed before coming to court. The lawyer may unsuspectingly lead the cross-examination into muddy waters for the witness, leading him to contradict or correct himself. This is detrimental to the impression he wants to establish.

Summary

In this brief article, it has not been possible to record all of the important considerations for an expert witness preparing to enter court for the purpose of presenting his testimony and/or evidence. However, several salient factors have been brought out:

1. Do not argue with the attorney.
2. Comport one's self with dignity.
3. Establish an air of authority and qualification for the presentation of the testimony.
4. Present the testimony in a clearly understood manner on a layman's level.

With these thoughts in mind, the engineer should have no difficulty in creating a favorable impression.

Some Findings About Visual Aids in Engineering Education

By ROLAND W. PINGER

Lecturer in Mechanical Engineering at Univ. of California at Berkeley, Colonel (Ordnance) U. S. Army, Retired

As a teacher of engineering passes middle age, he encounters an old dilemma. Should he continue his search for new facts to be added to the world's knowledge, or should he check, analyze, interpret, and publish those which he has already found? He could, of course, do all of these things, but in this paper I shall emphasize the last two only. For this task I am aware of a semantic limitation applying to many older writers—the fact that younger men have re-discovered old ideas and given them new, precise and polysyllabic names. The oldsters have heard most of these specific terms, and have profound respect for them. Unfortunately age does not improve the memory, so I ask my readers' indulgence when I use only simple engineering English to express some of my *findings* about visual aids in engineering education.

Many Languages

In my teaching, military and academic, and even in the education of my descendants I have been impressed by the great difference between human beings, in the reception and transmission of ideas. Men wishing to influence their fellows therefore appeal to the eye as well as to the ear, and in appropriate cases, to the nose, palate or finger-tips. Moreover, having selected one sense, say the aural, they modify their approach according to the desired objective—to entertain, instruct, persuade, or induce, as the case may be.

It is not strange, therefore, that men have developed *many* "languages," of which, for us, oral and written English are the most important. Judging from the speeches and essays of my students in "Professional Aspects of Engineering," these are also the most neglected in the pre-college training of our embryo engineers.

Music is another of these twin languages. The vibratory form is not easily expressed in words, but it is interesting to note that the *written* version has come down through the centuries as a kind of graphical Esperanto, based on what are really Cartesian coordinates. Mathematics is still another language, and we are forever indebted to the Arabs for delivering us from the clumsy Roman notation which might have imprisoned our numerical souls.

In the transmission of *certain* ideas, however, none of these languages suffice. Crude murals in the caves of Spain described the bison better than a thousand words from Confucius, had he then been born. In fact, had the sage copied the pictures in his own day, his simplified duplicate might have become the official Chinese character, or *ideograph*, for the unfamiliar bovine.

Pictorial representations take myriad forms—sketches, drawings, paintings, graphs, figures, diagrams, to mention only a few. Limiting our discussion according to purpose and desired response, we must leave to others the languages of amusement, esthetics, forensics, advertising, and the like, and concentrate on *instruction*. We must show objectively

how to transmit knowledge of *all* kinds, and subjectively how a student may learn to distinguish between the true and the false.

Some Findings

So we come belatedly to *some findings* about visual aids in engineering education. Subject to later elaboration the most important are as follows:

a. In the teaching of certain concepts with a minimum of ambiguity or error, words often must be supplemented, or even replaced, by visual aids.

b. In developing visual aids at the collegiate level, little help may be expected from existing educational sources. The latter are usually related to lower school levels, involving different purposes and responses.

c. Likewise, little help may be expected from existing commercial sources. Even the vendors of "overhead" projectors find collegiate demand insignificant as compared to that of lower schools and business enterprises. There is doubtless more money in selling ready-made films, strips, and slides the year around, than in selling a projector once in a generation.

d. Unless the collegiate teacher has time, patience, and skill, or commands the services of a talented assistant, he had better adhere to his chalk and blackboard, which cannot be excelled for many purposes. On the other hand, even if worthless as a *learner's* aid, a visual device may serve a useful purpose in clarifying the teacher's mind as no mere words and numbers will do.

e. The objective of any visual aid should be to provide a broader and more accurate mental conception of the matter otherwise presented—not merely to "sugar-coat" it. Such real understanding is indispensable if the student is to develop engineering judgment, and the intuitive ability to accept truth and reject error.

f. Finally, and most important of all, visual aids can be quite deceptive as to effect. After spending hours in their design and fabrication, the teacher may find that, from the student's viewpoint, they "go in one eye and out the other." My own belief is that in the engineering field, unless a *copy* of the aid is provided for home study, the aid is seldom worth showing.

Amplification of Findings

The "engineering method" does not encourage the stating of conclusions before the pertinent facts and analysis thereof. In any event it insists upon an *array* of the latter, no matter what the arrangement may be. This requirement, however, is incompatible with present space limits. So, in the light of many years of experience in the use of visual aids in both military and academic atmospheres, I shall merely amplify my lettered findings. You will observe that these overlap, or are related to each other.

Finding *a* (basic need for visual aids) is not very original. Our engineering textbooks are full of tables, graphs, diagrams and figures each of which is expensive from the publisher's viewpoint, but presumably worth the cost. These are all learner's aids. If the instructor wishes to use them as *teacher's* aids, or to expand that use, he may have to develop dozens of his own. Under these circumstances my preference is to *face* my students with a modern "overhead" projector, and with an efficient modern screen, which can be used instantly without darkening the room, or interfering with ventilation or note-taking. With a little experience these devices become as casual as the traditional chalk and blackboard. "Slides" will be discussed later.

In connection with *b* (help from educational sources) I should like to mention two exceptions. First, the educational services of the Armed Forces are apparently far ahead of the universities in the matter of high-level visual aids. One explanation is financial; another is a disbelief in the Mark Hopkins–log tradition,

according to which Mark did not even need chalk and blackboard.

As a second exception I must mention "A Graphic Approach to Economics" by K. William and Lore L. Kapp (Henry Holt and Company of New York, 1951) and particularly its preface, which should be read by everyone interested in graphic methods. This book, of course, is a learner's aid. If I were using it, I should convert much of it into "slides."

Item *c* (help from commercial sources) was a great surprise, when my Alma Mater eventually bought me a $200 "overhead" projector. The manufacturer's literature implied that making "slides" was a very simple thing. Actually it took more than a year's research to find a *black ink* that met my specifications for use on cellulose acetate. Like Edison in his search for rubber, I tried almost everything, but finally evolved a simple solution—ordinary clear lacquer dyed with "Speedry" or equivalent transparent black or colored ink. One salesman, accustomed to the well-financed operations of the advertising business, suggested that I simply turn my problem over to my "art department"; he was amazed to find that I was *it*.

On the other hand, the same gentleman suggested the "ozalid" and related photographic processes, which are probably more practicable for those who dislike using colored lacquer in a ruling pen. My ultimate techniques in the *design, production and use of large slides* (to which I am still adding) may be material for a sequel to this paper; in the meantime I offer free consultation service. "How to Prepare Transparencies for the Vu-Graph Projector," published by the Charles Beseler Company in April 1953, is useful but not complete.

It was also something of a surprise to find that commercial magazines devoted to audio-visual matters should contain so few articles on "overhead" projection and transparencies therefor. Mr. James C. Beaver's "Music Overhead" in the March 1954 number of *Educational Screen*, however, may indicate a change in trend.

The technological difficulties of *b* and *c* have their ideological counterparts in *d* and *e* (toil and objective). I have discovered that a vague paragraph is easy to write, but can be quite difficult to translate into explicit graphical form. Assumptions must be made, constants replaced by variables, and unmentioned alternatives introduced. The result is often highly informative, and even more fundamental in its implications than was contemplated by the original author. Nevertheless, much time is required, and one must balance that factor against other commitments. Perhaps the best method is to suggest the problem to one's students, and *let them work out the details*, thus converting a teacher's aid into a learner's aid.

As to *f* (effectiveness) I learned thirty years ago that projecting an idea into the eye of a student did not necessarily file it in his brain. Teaching ordnance engineering to upper-classmen, I used four or five hundred old-fashioned $3\frac{1}{4}'' \times 4''$ lantern slides. I took the precaution, however, to get one of our arsenals to supply each student with a set of blueprints from the related negatives. Although small, these prints and accompanying mimeographs "recalled" my lectures at will. Middle-aged men (colonels and lieutenant colonels in World War II) still flatter me with favorable memory of this unusual procedure.

Teaching "Engineering Economy" since my retirement from the Army, I have encountered the same problem with 400 modern $8'' \times 10''$ slides of my own design and manufacture. Up to now I have found no duplicating process quite cheap enough, but I still have hope. In the meantime I believe that in comparing students who have *not* been exposed to visual aids with those who *have* (but who have received no copies for home use), little difference in assimilation will be found. This may be disappointing to

visual aid enthusiasts, but I fear that it is true, at least in engineering education.

Conclusion

In conclusion I believe that we are only on the threshold of education through the eye. Until an organized "grammar" of visual presentation is evolved, we must work by trial and error, and without being too easily discouraged. We must constantly test our methods by measuring our results. Finally, we must learn to discard unprofitable techniques, no matter how much love and labor we have bestowed upon them.

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Discussion of "Engineering Education Across the Country"

By D. L. TRAUTMAN

Department of Engineering, University of California, Los Angeles

Many interesting responses have been received relative to the above paper in the November 1954 issue of the *Journal*. In the words of one, "I found it stimulating and to the point. I would be pleased to hear about other reactions to it—particularly by engineering teachers." It appears appropriate to report the reactions of those who responded to this and to an advance distribution of the paper last spring; the several dozen replies came from a cross-section of engineering staff from Dean to Instructor. The body of this present note thus consists of representative portions of these comments in continuous context.

"An excellent and concise report which should stir up a lot of constructive thinking. Perhaps my mental outlook is not as old as might be considered from the length of time I have been teaching, but I find myself in almost complete agreement with not only your observations but also your suggestions.

"Your article is of particular interest to me. My assignment at the present time is to make a study of Engineering Education. . . . It has been my personal observation that the situation throughout the country is very much as you described it. I had an opportunity to visit about thirty engineering colleges last year and gained a very depressing impression.

"I was very glad to receive your letter and article in Paris. I must admit, however, that your findings and my observations in the few weeks that we have been back in this country have been somewhat discouraging. Many of the criticisms which you make are remarkably close to those I made of various schools abroad.

"Unfortunately engineering education in other countries is also reasonably close to your outline. In some cases the aim is even less laudatory than the preparation of students for entrance into a career. It sometimes degenerates into something which approaches a degree factory. This is doubly unfortunate in some of the countries concerned since such an enormous number of problems remain to be solved in them that methodology and decision-making are apt to be much more important than mere factual knowledge.

"It has also been my observation that it is not common to find the combination of aggressive leadership and staff. I am sorry to note that it does not appear in the U. S. on a large scale either.

"I found myself irritated by feeling that the paper supported a preconceived thesis instead of reporting objective observations.

"Such phrases as 'essential essence of engineering education' are difficult to interpret. What essence of engineering is not essential? What do you mean by a fact? If a fact is defined as anything which is true, what is the difference between a fact and a concept, or is a concept which is not a fact of any value? How can anyone get an understanding of concepts or ideas or of disciplines except through facts?

" 'Training for routine doing'—depends upon implications of the word routine. (*a*) If we prepare students to handle varied engineering assignments in a 'rou-

tine manner,' that is, by employing a scientific approach whenever necessary, and solving by application of the proper fundamentals—then we are accomplishing something. (*b*) If, however, it is the *problems* that are routine, and the students are unable to solve any others, then we are not even one step above technical training.

"'No concerted attention is given the gifted student'—I believe our most urgent present problem is to concentrate first on raising the general level of our engineering education—then worry about taking the gifted student even further. It appears to me that the essence of Engineering is 'systems' in the broadest sense. However, after the perusals I have made of various engineering school catalogs I am of your opinion that the undergraduate program is almost devoid of any systems or synthesis work.

"I do not see that the primary emphasis on lectures is necessarily bad. This presumes, of course, some student preparation prior to the lecture and that the lecture is not merely a reading from a textbook but an extension or emphasis of interesting topics. Some of the discussion necessary for straightening out ideas in the student's mind ought to come while working assigned problems. If these problems are of more than merely routine nature, their correction can serve as a very nice feed-back mechanism to keep the lecturer informed as to the progress of the class. (This, of course, assumes a reasonably sized class.)

"My own opinion would be that integration on the basis of method is of more use than that on the basis of content.

"It really would be quite valuable to have a summary of what trends actually are. You do half of this job in the part of your paper listing tendencies toward change. I should be equally interested in the other half of the picture, listing tendencies toward remaining unchanged. It would be quite valuable to have a report of your observations telling what changes are being made and what changes are not being made.

"I believe we have attempted to remove many of the factors which you have indicated hamper a vigorous evolution of engineering education, principally by giving our younger members of the faculty broad latitude in arranging their programs.

"For several years we have given a comprehensive examination as part of the requirement for the first engineering degree which, in our five-year program, happens to be the Master of Science degree. In part 4 (j) of your paper you mention a senior comprehensive in engineering. We are engaged in a re-evaluation of our comprehensive examination requirement and are interested in learning of the experience of other institutions.

"Too many courses everywhere have 'grown' into the supervised study class of operation,—the product being learners instead of creative individuals.

"The ideas you have gathered from your study are stimulating and helpful. However, I gain the impression that we need to be sure we have our feet on the ground and are not carried away by pedagogical balloons.

"Your observations seem uniformly critical, except toward experimental procedures. While, admittedly, overemphasis of deficiencies may be necessary to obtain approval for a change, a proposal for a new approach is greatly weakened in the minds of realistic and thoughtful teachers if it does not point out the strong, as well as the weak, points of the system it is to replace.

"It certainly makes clear that we have a long way to go to make education really effective. As a matter of fact this kind of challenge has been one of the things that makes education attractive to me as a field to work in."

Candid Comments

Thermodynamics for Chemical Engineers

By F. M. TILLER

Dean of Engineering, Lamar State College of Technology

In an article published in the November, 1954 issue of the *Journal*, Professor A. B. Cambel proposed the teaching of a well-integrated series of courses in thermodynamics, fluid mechanics, fluid flow, and allied courses. Very aptly he suggested that the solution to improving inadequate subject material did not consist in simply adding more advanced courses. Too often engineering teachers burden the curriculum with new material rather than solve the basic problem of teaching a student thoroughly at the first opportunity. While repetition is excellent and necessary if planned properly, it is not infrequently boring and wasteful of precious time. The proposals of Professor Cambel would help solve some of our problems involving repetition and integration.

While Professor Cambel has recommended a five semester sequence, it is my opinion that the special problems of a chemical engineer require more time. Fluid flow, heat transfer, and the introduction to thermodynamics are virtually the same for all engineers; but beyond these courses, the chemical engineer must be further trained in Gibbsian thermodynamics, phase rule, kinetics, and many of the topics included under the heading of physical chemistry. In designing a new curriculum in chemical engineering at Lamar Tech, a program was initiated which is based on much of the same philosophy discussed by Professor Cambel. Basically the sequence of courses is as follows:

1. Introduction during sophomore year
   a. First semester: material balances, vapor pressure, latent heat, ideal and non-ideal gases, critical phenomena
   b. Second semester: first law of thermodynamics, thermochemistry, fuels and combustion, phase equilibria, Raoult's law, Henry's law
2. Thermodynamics during junior year
   a. First semester: first and second law, vapor cycles, heat engines
   b. Second semester: properties of non-ideal substances, Maxwell relations, Gibbs and maximum work functions, physical equilibria, chemical equilibria
3. Allied courses during junior year
   a. First semester: fluid mechanics
   b. Second semester: heat transmission
4. Senior courses
   a. First semester: third law of thermodynamics, kinetics of chemical reactions
   b. Second semester: kinetic theory, spectroscopy, colloids, statistical mechanics

In addition, a junior course in modern or solid-state physics is required. The order of subject material is somewhat different from that suggested by Professor Cambel but generally covers the same area.

With respect to laboratory work, I would disagree with Professor Cambel in having lecture and laboratory run concurrently. It seems preferable to plan the

lab course to follow the lectures by at least one semester. When the two are given during the same semester, it is difficult to schedule experiments so that classroom theory is always synchronized with laboratory needs. When laboratory instruction follows classroom work, a desirable repetition and review is effected.

The position of the traditional course in physical chemistry as based upon Daniel's textbook presented a knotty problem. The chemical engineering department was of the general opinion that the repetition of the first and second laws between physical chemistry and thermodynamics was unnecessary and that the usual physical chemistry treatment was too cursory. As an experiment, the first semester of physical chemistry was dropped, and chemical engineering students went directly into the second semester. While this plan was successful, expansion of the sophomore course and introduction of advanced physics made the overlap with physical chemistry too extensive, and it was temporarily dropped from the program. In following the development of sophomore chemical engineering courses throughout the country, I have come to the opinion that educators should carefully scrutinize the present physical chemistry course in relation to what is being taught in other courses. Where the introductory course in chemical engineering has been expanded and chemical engineering thermodynamics is included, the physical chemistry course should either be eliminated or modified.

Teaching Tips

Construction of a Demonstration Slide Rule

By WILLIAM K. VIERTEL

Instructor, State University Agricultural and Technical Institute, Canton, N. Y.

The design and construction of a demonstration slide rule might under some circumstances make a good student project. Making the calculations teaches something about logarithms, and organizing and carrying out the job of computation has an educational value. Putting logarithms to a directly useful purpose such as this provides powerful motivation.

The writer has found it possible to construct such a rule, 8 feet long overall with scales 2 meters long, which can be seen from the back of a fair-sized classroom and which works smoothly. It was made using only tools and materials which are easily available, with no skilled labor except for making the slides and grooves. This article is to record some of the details of the construction for the benefit of any others who might wish to build such a rule. Since factory-made rules like this can be bought for $25 to 30, the project is not recommended as a means of saving money. Its worth, if any, lies in the educational value to those who do the work.

The writer built this rule unaided except for the making of slides and grooves, which was done by a skilled workman using power tools. The rest of the work took the equivalent of about two to three weeks of full-time effort, and the result was a rule with the following scales: A, B, C, D, CI, DI, CF, DF, CIF, K, L, LL3, S, T, and ST—in other words, the equivalent of the Keuffel & Esser "Polyphase Duplex Decitrig" or the Pickett & Eckel "Ortho-phase," model 1000, plus one log-log scale. Other log-log scales could have been added, but were not needed in our situation.

The most difficult part of the job might be to get seasoned lumber. The writer was fortunate in being able to find some salvaged boards which were dry and straight and which, when planed, nail-holes and knot-holes filled with plastic wood, shellacked, and painted with two coats of flat white, made a fairly good appearance. Two boards, $\frac{3}{4}'' \times 6'' \times 8$ ft. were used. One of them made the slide; the other was cut in half lengthwise for the two pieces of the body, which were $\frac{3}{4}'' \times 2\frac{3}{4}'' \times 8$ ft.

The slide was grooved on both edges, and the two pieces of the body were grooved on one edge with power tools, to make a tight fit on smooth splines $\frac{3}{8}'' \times \frac{3}{4}'' \times 8$ ft. The splines were glued to the slide to make tongues on each edge, and then the tongues and the grooves in the body pieces were sandpapered until a smooth sliding fit was obtained.

The end-pieces which held the two halves of the body together were made of $\frac{1}{4}''$ plywood cut to resemble those on an actual rule and painted with aluminum paint. Six $\frac{1}{4}'' \times 1\frac{1}{4}''$ bolts and washers held the assembly together, using extra washers to provide space between the end-pieces and the slide so that it would not rub.

Calculations for the scales were made all at one time and arranged for easy reference. To lay out the scales, the division marks were first located with a sharp nail and a meter stick. They were then drawn in with a ruling pen and

black drawing ink. It was necessary to protect the lines from rubbing until one side of the rule was finished, when it was given a coat of clear varnish.

The numbers, letters, and other markings were put on the rule using rubber-base paint which comes in tubes having a ball point,* making it very easy to apply and fast-drying.

For the indicator "glasses," two pieces of clear transparent plastic $\frac{1}{8}$" and 7" wide were used. (The other dimension would depend on the overall width of the particular rule—in this case, 13".) The "hairlines" were put on the inside surface of the indicator "glasses" using the same rubber-base paint that was used to apply the numerals.

It is recommended that the boards for the two pieces of the body should be 4" wide instead of $2\frac{3}{4}$" if four more log-log scales are to be added to the rule here described.

The writer would be glad to furnish further details to anyone who is interested.

* Available from Tri Chem Inc., 82 Main St., W. Orange, N. J., in 1- and 2-oz. tubes costing 75¢ and $1 respectively. Many colors available, including red and black.

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364 new members elected this year

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 29–30, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 7, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Swarthmore College	May 7, 1955	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	March 26, 1955	M. M. Jones, University of Missouri
National Capital Area	Catholic University	Oct. 5, 1954	J. C. Michalowicz, Catholic University
New England	Massachusetts Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	A.F. Inst. Wright	Sept. 17–18, 1954	K. F. Sibila, University of Akron
	University of Akron	May 7, 1955	
Pacific Northwest	University of Idaho	April 15–16, 1955	M. L. Jackson, University of Idaho
Pacific Southwest	University of California, Berkeley	Dec. 28–29, 1954	B. M. Green, Stanford University
Rocky Mountain	Colorado A. & M. College	April 16, 1955	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9, 1955	V. L. Doughtie, University of Texas
Upper New York	Cornell University	Oct. 22–23, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

Do You Know—

► By now you know the Annual Meeting is at Penn State on June 20–24, and have received the Preliminary Program. To facilitate your planning, "How to Get to Penn State" is repeated below. It is expected most people will drive and you will appreciate the convenience of having your car.

By highway, the intersection of highway routes US 322 and Penna. 45.

By bus, the Greyhound Bus Lines from Pittsburgh, Harrisburg or Scranton, Penna.; the Edwards Bus Line from Elmira, N. Y., by way of Williamsport, Penna., and from Cleveland, Ohio.

By train, the Pennsylvania Railroad from the west to Altoona, Penna. and then by Greyhound Bus Lines (42 miles); from the east to Lewistown, Penna. and then the Boalsburg Bus Line (30 miles). To avoid excessive delay between train arrival and bus departure, schedule arrival at Lewistown or Altoona to coincide with the bus schedule.

By air, the Allegheny Air Lines from Pittsburgh and Newark to Mashannon airport and then a taxi (25 miles) to State College (University Park).

► Members of all Divisions of the ASEE are invited to visit the exhibits of the Engineering Drawing Division at the Penn State meeting. The exhibits include instruments, reproduction processes, student work, tests and quizzes. Here is an opportunity to learn at first hand the kind of work the Division is currently doing.

► The Chemical Engineering Division is sponsoring its fourth Summer School at Penn State, June 27–July 2, 1955. Typical of the technical presentations are reaction rates, process rates, fluid mechanics, solid state physics, design, and operational research; an entire day is devoted to mathematics in Chemical Engineering; accrediting of undergraduate and graduate curricula, a symposium on unit operations versus engineering science, and round table discussions on the teaching of the first course in various areas such as thermodynamics, unit operations, and economics are also included. Staff members of the host institution will give a series of four lectures on educational methods and a presentation on student counselling.

► As a reminder of what you read last month, these meetings are also being held at Penn State: *English Summer School* on June 23–25. *Open Conference on* the teaching of *Thermodynamics,* limited to 125 persons, on June 27–29.

► "University Park" is the Post Office address of the Pennsylvania State University, the post office being located in The Hetzel Union Building. State College is still the name of the city and it has its own "State College" post office.

► The Hetzel Union Building is a new addition to the Penn State Campus. It was financed by a student-voted assessment and alumni and administrative contributions. It was opened on March 15 of this year and its facilities will be available for all to enjoy at the Annual Meeting. It is "modern as the word go," has tremendous lounge space, reading rooms, dining rooms, grill and snack bar, TV Room, photography room, card room, game room, seven soundproof listening rooms for playing records, an art gallery, an assembly hall seating 196, and a ballroom seating 650 with an immediately

adjacent open-air deck almost as large as the ballroom. There also are offices and eight meeting rooms for student activities. Penn State justifiably can be proud that the "HUB," the letters coming from the name Hetzel Union Building, has replaced the "TUB," the Temporary Union Building moved from Lebanon, Penna., to Penn State in 1948.

► The dormitory facilities at Penn State are very extensive, a great many having been built since World War II. Those assigned to ASEE use are on campus, just a few blocks from the Union Building and the Nittany Lion Inn. The Inn is a large University-owned and operated facility for transient guests and visitors.

► A summer course in Plastic Design in Structural Steel will be held at Lehigh University, Bethlehem, Penna., on Sept. 7–15, 1955. The course is sponsored by Lehigh University and the American Institute of Steel Construction in cooperation with the ASEE and the American Society of Civil Engineers. The course is for educators in particular and is intended to enable them to introduce some of the new concepts into their teaching. The course will review the behavior of steel structures loaded beyond the elastic limit and will include the fundamental concepts of plastic analysis. Specific plastic design techniques will be presented and examples worked out. The series of lectures and demonstrations will involve the study and testing of columns, continuous beams, full-size connections, and a complete frame.

► ASEE members will be interested to know a Nuclear Engineering and Science Congress will be held in Cleveland, Ohio, December 11–17, 1955. The Congress is sponsored by the Committee on Nuclear Science and Engineering of Engineers Joint Council, of which ASEE is a constituent society. Twenty-four national engineering and scientific societies have united as sponsors and co-sponsors, the total membership of all being 250,000. The Engineers Society of Cleveland is in charge of local arrangements and Professor Donald L. Katz of the University of Michigan is Chairman of the Program Committee.

► ECPD has announced the expansion to the Detroit area of its pilot-study of the program for young graduate engineers known as the "First Five Years of Professional Development." The program, successfully tried in Cincinnati, is designed to offer the young graduate engineer a sound plan for continuing personal and professional growth.

► We are receiving enthusiastic comments on the new EDUCATIONAL AIDS catalog. Have you ordered your copy yet? The catalog is available from ASEE headquarters at $1.00 per copy.

► The office receives many requests for membership application blanks. We are happy to send them out, but remember there is an application blank on page 4 of the Yearbook. How about everyone putting that page to work?

W. LEIGHTON COLLINS
Secretary

Evaluating Good Teaching*

By R. D. STOUT

Professor of Metallurgy, Lehigh University

Introduction

In almost every University catalogue one will find a statement of educational objectives by which the college is committed to "stimulate the student in independent thinking" or "prepare him in the art of living" or "train his mind for the analytical solution of problems in industry and government." The teaching staff is the principal instrument through which the college must meet these objectives. In the selection of staff members for an engineering college there is a considerable tendency to be casual about qualifications for teaching, and to emphasize instead the requirements of ability in research.

With the instructor on the job, the administration then faces the problem of applying some sort of measuring stick to the calibre of his teaching. From conversations, I gather that department heads depend largely on the "grapevine" to learn about the performance of an instructor. This indirect information plus the professional accomplishments of the man are about all that the administration has to guide its judgment. It has, however, the advantages of time and personal contact for reaching an evaluation. The outsider who wishes to rate teaching at an institution as a part of an accreditation lacks even those advantages in his difficult task.

This paper does not pretend to suggest a procedure for evaluating teaching but it does attempt to discuss some of the factors that require consideration in the development of such a procedure. The importance of this question to the general problem of accreditation needs no comment.

The Eelements of Good Teaching

At the outset of the discussion, it must be recognized that the characteristics of good teaching are largely intangible. Anyone who recalls his own undergraduate classes can pick out certain of his instructors who have left a lasting impression as good teachers. Yet if he is pressed to explain these impressions in detail, he finds them difficult to reduce to specific items. Good teaching is a complex, built from the character and personality of the teacher, his relations to his students, and his general status and reputation as an engineer, as a faculty member, and as a citizen of the community. These factors do not readily respond to objective analysis.

The outsider, therefore, must begin with an appreciation of the limitations forced upon him. He must content himself with the outward manifestations of these intangible characteristics, as far as they can be observed and evaluated. Some of the sources of evidence will be considered here.

There are three general categories in which evidence of teaching ability can be found. They are:

a. the man's reputation and activity as an engineer
b. his reputation as a teacher among former students
c. the tools with which he teaches

* Presented at the Annual Meeting of ASEE, Educational Methods Division, University of Illinois, June, 1954.

These are the most promising avenues of approach for the evaluation of teaching.

The Teacher's Competence as an Engineer

Almost without exception, activity in engineering work is a prerequisite to authoritative teaching. Since engineering deals with things, it cannot be mastered in the seclusion of a library or private office. Both the past experience of the individual and his current professional activity are pertinent.

Industrial experience as a background is almost indispensible in the engineering field. I have seen among my students how greatly industrial work has enhanced the soundness of their approach to classroom and laboratory problems. So much more, then, does the instructor need such background.

Engineering is such a dynamic field that one is hard put to keep up-to-date even in his own specialty. The current activity of the instructor therefore must also be examined. In addition to research work and its publication other activities, such as technical committee work, consulting, outside lecturing and textbook writing are valuable as adjuncts to teaching.

The Teacher's Reputation Among His Students

The persons in the best position to observe the ability of an instructor are his students, and it unfortunate that they are *not* the best qualified for passing judgment. At the time he takes the course, the student is apt to be prejudiced by temporary factors such as his last quiz grade or the length of the latest assignment. On the basis of the student evaluation forms, it has been my experience that the students are capable of making valid comments on the performance of the instructor at the end of the term. There is relatively little tendency for those who have done well in the course to rate the instructor highly and for those who have done poorly to be hypercritical.

There are some staff members who oppose student evaluation and class it as a popularity contest. Undoubtedly there is some connection between the personal relations of the instructor and student and the rating rendered by the student. But certainly one does not have to be disliked to be good at teaching!

Probably a time lapse of one year is optimum for a fair estimate from the student. Before then he remembers the trivialities, and much later he may have forgotten the specific performance of the instructor. It is quite possible for a teacher to show very uneven quality among his courses. He may devote too much attention to those he likes and neglect the less appealing classes. It is not what an instructor can do, but what he has done that counts.

It is possible that the seniors might be given a questionnaire which would provide information supplementary to the other sources of data. The validity of such information would be hard to foretell without a trial.

The Tools of Teaching

The teaching of engineering subjects requires a number of standard mechanical aids, such as assignment sheets, lantern slides, charts, exhibits, demonstrations, and the textbook and outside references. It is helpful to observe the use to which the instructor puts these devices. In addition, it would be necessary to interview the instructor himself to learn his personal attitudes toward teaching.

One of the most significant sources of evidence is the quiz form. For one thing it is a sample of the subject matter that the instructor considers important and assumes he has covered adequately in class. Secondly, it shows the general approach used by the instructor in conveying an understanding of engineering principles to the students. A form of quiz which requires the student to reason and to apply the information covered in the course is readily recognized to be superior to one requiring only a repetition of facts

picked up in the textbook or in the classroom. It would be unrealistic, however, to expect the student to reason out solutions if he has not been given the necessary background in class. Thus, the quiz form is apt to be a reliable indicator of the teaching techniques followed in the course. Third, quiz sheets completed by the students help to show how they are responding to the efforts of the instructor. Finally, the quiz is useful as an educational device, and it is worthwhile to find what advantage the instructor takes of this fact.

There are other measures of the effectiveness of the teacher in stimulating the minds of his students. These include his use of work projects, field trips, class discussion periods, and office hours for individual help.

One comment is necessary here on the curriculum. No matter how capable he is, the instructor is circumscribed in his efforts by the curriculum in which he works. Thus, the curriculum should be examined from the viewpoint: does it foster good teaching? The connection between the two is not always recognized.

General Comments

In summary, it must be reiterated that there is no easy and accurate method for evaluating teaching; if there were we would not continue to discusse the subject. Teaching is an art and does not lend itself to objective evaluation. The human element in teaching overshadows the mechanical features to such an extent, that any suggestions that can be made here are of limited usefulness. In some respects, a "good" teacher is as hard to describe or evaluate as a "good" parent. One is forced to deal with broad generalities or trivial details without ever reaching the heart of the matter.

It is possible, nevertheless, to detect signs of inferior or superior teaching. These will be apparent as deficiencies or capabilities in the professional activity of the instructor, in his reputation among his colleagues and his students, and in his use of the tools of teaching. Certainly more can be accomplished in this direction.

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Publication as a Motivation for Advanced Students

By JOHN S. McNOWN *

Professor of Engineering Mechanics, University of Michigan

Introduction

To an advanced graduate student the goal of having his work published is a remarkably effective stimulus to sound learning. The strong motivation of an original project enables him, with only limited guidance, to develop in ways which cannot be effected by classroom assignments. Complete technical papers may be beyond him until he has completed a thesis; but from his work in specialized courses, he can prepare a note, a discussion, or a part of a composite publication.

Mature students who have had this type of experience heartily endorse its effectiveness. In conducting original projects, they broadened their knowledge of the topic, posed and tested hypotheses, collected or reviewed data, and conducted or adapted analyses. Finally, they faced the exacting labor of preparing a manuscript from the original organizing of their ideas to the final clear and logical expressing of them.

Few young students know whether an idea is novel, or have the judgment to distinguish a worthwhile problem from a trivial one. In the conceiving of a problem and in the making of occasional major decisions, some guidance is necessary. However, a suggestion or two usually enable them to visualize at least the outlines of an undertaking. Subsequently, they require from the adviser less of prodding than of restraint.

Feasibility

Of course, if the student's work is to appear in print, publication media must be available. Fortunately, they are. With the wide variety of journals, symposia, bulletins, and conference proceedings—both domestic and foreign—an engineer has an opportunity unequalled in any other profession. Even though major journals often have a sizable back-log of accepted papers, rarely if ever is there difficulty in finding an outlet for valid contributions. Moreover, journals in such bordering fields as physics, applied mathematics, and instrumentation are interested in appropriate papers from engineers. As an illustration of the large number of outlets available, publications of the Iowa Institute during the past 10 years have appeared in 25 scientific journals and in the proceedings of some 15 technical meetings; about a third of each group were foreign.

The prevailing standards of acceptability need not and should not suffer because of publication of the work of graduate students. Editing by the adviser permits holding the student to the present acceptably high standards. Counsel is often needed in the selecting of material and in the interpreting of findings. The more difficult decisions, because of the student's enthusiasm and inexperience, may be those to refrain from saying something.

Discussions

Discussion of the published work of someone else is one type of contribution

* Formerly Associate Director, Iowa Institute of Hydraulic Research.

within reach of a graduate student. Formal discussion, which is actively fostered in several of the leading engineering journals, or a discussion type of letter to the editor is particularly well suited to his capabilities. From a wide variety of current topics, he can choose one which interests him and about which he is at least fairly well informed, and he can prepare a comment ranging in length from a few paragraphs to a number of pages, and varying in content from corrections and additional bibliographic material to reinterpretation or extension of the author's findings. The fact that the author has the last word in his closure is an effective deterrent to the submitting of carelessly prepared comments.

In the past three years eight discussions have been prepared by graduate students in the department of Mechanics and Hydraulics at the State University of Iowa, and perhaps an equal number have been stimulated by correspondence with former students. Some developed from classroom assignments; others were almost completely self-generated. The projects were beneficial to the students, and the achievements reflected credit on the department.

M.S. Theses

Another type of contribution is derived from the M.S. thesis. Although not always containing sufficient material to be publishable as a separate paper, other possibilities exist. The thesis can form the basis for an excellent discussion, or a coordinated series of theses can be combined into a complete publication. Also, after a thesis has been satisfactorily completed, the investigation can be continued as an independent project or in collaboration with a staff member or with another student.

A variety of publications, mostly with plural authorship, have arisen out of theses submitted to the Mechanics and Hydraulics department at the State University of Iowa. During the past ten years, almost half of more than sixty publications of the Iowa Institute which appeared in standard journals were based either entirely or in part on graduate theses. Because of the numerical predominance of M.S. theses over Ph.D. dissertations, a slight majority were based on the former. Altogether, theses have provided a core of fundamental investigation in the Institute's comprehensive research program.

Group Projects

Contributions arising from special course work are exemplified by the results of a project which began as an advanced class in hydrodynamics in 1951 and culminated in an 82-page bulletin published two years later. Of the twelve who participated, eleven were then enrolled for at least part-time graduate work. The general subject, the Helmholz-Kirchhoff free-streamline theory, was selected for study because it is important in hydrodynamic analysis and because it served in solving several significant problems. Assurance was given to the participants at the outset that papers presenting the anticipated results would be publishable.

After completing a review of the topic and making a series of reports on outstanding references, the students undertook specific analyses. Some of these required a considerable amount of mathematical analysis, all required a detailed understanding of conformal transformations of complex functions. Because many analyses on this topic published in the past had been conducted with a disregard for the reality or utility of the result, topics, such as the form of boundary transitions and the characteristics of the deflection of jets, were chosen for their practical importance. Comparisons between observed and computed results were made for each type of flow, so that tested solutions to significant problems were obtained.

Although the eight papers in the resulting bulletin have intrinsic merit, their content is perhaps less important than

was the resultant growth of the authors. A group of young engineers, including several who were not strongly inclined toward mathematics, mastered one phase of complex function theory. They made a rather thorough survey of the significant publications including work by such giants of the 19th century as Helmholz, Kirchhoff, and Rayleigh. They applied judgment to the selection of worthwhile problems, and, before a group of critical staff members including an instructor of oral and written expression from the department of English, they presented orally their findings. Finally, they prepared illustrated manuscripts. Throughout the project, an outstanding feature was their readiness to complete an amount of study and analysis far greater than that expected for the academic credit received.

Opportunities like the one described in the preceding paragraphs may seem exceptional, but almost any specific project would so seem. Every specialized interest of engineers can profit from well directed investigations even if limited in time and scope. Students can assemble and interpret available results or complete unfinished projects proposed by workers who have neither the time nor the patience for detailed work, and they can conduct pilot studies in the laboratory. If not individually, at least in the aggregate, the accomplishment can be surprisingly great.

A laboratory project led some years ago by Dr. Hunter Rouse, Director of the Iowa Institute, illustrates a type of project entirely different from the free-streamline analyses. In a special summer course lasting only 4 weeks three projects were undertaken by teams of three advanced students. Problems had been selected which were adapted to the facilities of the Iowa Institute: (1) flow near a free overfall, (2) the effect of a sill on a hydraulic jump, and (3) certain aspects of the transverse distribution of velocity in a pipe. These men set out to complete in this very short time experiments which would lead to worthwhile papers. Two of the three projects did mature to publication. In all three the challenge of the unknown was a remarkable stimulant.

Summary

Effectiveness of the goal of publication is the common thread in the diversified projects that have been described. The topic, the technique, and even the accomplishment are secondary to the awakening of the student to the challenge of the unknown. Although less important than this primary goal, the many by-products of original investigations are also beneficial to the student. Individual projects are the embodiment of learning by doing which should form a part of the training of every advanced student. In most projects a real need is found for the use of library facilities. As assistance from members of allied departments is often required, the student participates in interchange which illustrates scholarly cooperation. Finally, in writing or speaking his piece, the student becomes truly receptive to instruction on the importance of clarity, concision, and grammatical correctness. He can then be persuaded, if necessary, to seek clinical assistance from teachers of speech and technical writing.

By the time a student has completed one year of graduate work he is sufficiently mature that he can profitably undertake an investigation tailored to fit his interests and available time. Such projects can accelerate his growth, teach him both caution and confidence, and contribute to the acquisition of elusive qualities like initiative and inventiveness. Such extensive achievement is possible because his desire to emulate productive scientists provides a far stronger incentive than do grades or credits. The habit of working toward publication needs to be acquired, and its stimulation is a logical complement to the other processes of formal education.

The Effect of the Graduate Program on the Teacher*

By PAUL F. CHENEA

Assistant Dean of Engineering and Head of Division of Engineering Science, Purdue University

The years since the war have been marked by a tremendous interest in teaching techniques for undergraduate engineering education. We have seen during this time the formation of a committee in the ASEE to foster the improvement of teaching and the organizing of a committee in most engineering educational institutions with this same objective. There have been lively discussions of this topic at national meetings and in a multitude of smaller groups of engineering educators and practitioners. The emphasis has usually been centered around the proper techniques for effective teaching and the ideal background and experience that makes an outstanding teacher. Many special programs have been established for teacher training, especially for the younger teachers and graduate students who are permitted to conduct classes. This wide interest and activity to provide better teachers cannot help but portend a better generation of engineering teachers.

There is one phase of undergraduate teaching, however, that has received relatively little attention and that is the frequent gradual loss in effectiveness which takes place in the professional undergraduate teacher over the years of his career. Today in almost all institutions we have teachers who are past masters at instructional technique but are not completely effective because of their limited knowledge of modern engineering practice or advanced subject matter. In fact the normal course of events for strictly undergraduate teachers seems to tend in this direction. It would appear to take some special effort on the part of the teachers and the administration to avoid this result.

The fact that a wide knowledge of the subject matter and its application to engineering situations is essential for a good teacher would seem to be axiomatic. In a recent interim report of the Committee on Evaluation of Engineering Education, ASEE, the committee stated "Every teacher should become a recognized expert in his field regardless of his background. For every teacher there is no substitute for knowledge of subject matter far beyond the limitations of that to be taught."

The report goes on to say that this in itself is not sufficient but that it is a key requirement. To this we all will heartily agree, but how does one keep up with the rapid advance of engineering if one directs all of his energies toward undergraduate teaching. The answer must be that such a teacher does not keep abreast of new knowledge. Something else must be injected into his daily life if he is to grow with the profession. There are many activities that can offer the needed stimulus to improve the breadth and depth of knowledge of the teacher. Occasional periods of actual practice in the profession in a responsible capacity is certainly one. Continued activity as a consultant offers many golden opportuni-

*Presented at the Annual Meeting of ASEE, Educational Methods Division, University of Illinois, June, 1954.

ties to keep abreast of the field. Appropriate research activities on and off the campus is another valuable approach. Probably the most effective however is the continued participation in graduate courses, study and research. There is nothing quite as stimulating as learning with a keen energetic graduate student.

If one looks at the undergraduate engineering program of today and compares this with that of thirty years ago it is quite apparent that much of the material in the present program is new. A sizeable fraction of this new material was once taught as graduate material. The remainder is new knowledge that has been generated by the profession, and much of it through graduate research programs. It is not unlikely that this trend will continue and that many of the future revisions of the undergraduate curricula will hinge around material now thought to be advanced and now taught as graduate subjects. Therefore what better preparation for tomorrow's teaching can there be than the teaching of some of tomorrow's subjects today.

Beneficial Effects

To be more specific there are several important and distinct ways that a graduate program can beneficially effect the undergraduate teacher. Three of these are the teaching of advanced courses, the supervising of graduate research and the conducting of graduate seminars.

The teaching of graduate courses differs from the teaching of undergraduate courses in many ways. More often than not there is no suitable text, and recourse must be had to the available treatises that bear on the subject. Further, a graduate course must reflect the periodical literature of the past and, more important, that of the present. Subject matter accumulated in this manner often possesses little continuity and must be recast to permit a clear and meaningful presentation. Frequently the literature itself is not complete, and appropriate bridges must be constructed to obtain any continuity at all. Often these gaps provide the stimulus for individual research and frequently they result in published papers that are real contributions to the literature. In short, the very act of teaching an up to date graduate course stimulates considerable growth on the part of the teacher and does much to increase his technical knowledge. This is true whether the course is primarily of a theoretical nature or one which reflects the latest art and empiricism in the field.

The good graduate teacher never reproduces a series of lectures year after year. He knows that last year's advanced course is no longer advanced in all its detail and changes are mandatory if it is to achieve its goal this year. This spirit of improvement carries over into his undergraduate teaching. He continually searches for more significant material for the beginning courses. It is most unlikely that these courses will become stale and out of date in his hands. Another effect of combining graduate teaching with the instruction of undergraduates is the change of pace that it offers. The pedagogical approach is different, and one does not get set in his attitudes and teaching techniques. A graduate teacher is much more likely to experiment with teaching techniques. He will often try some of his graduate teaching tricks on the undergraduates, and vice-versa. All of this creates a healthy environment for both the teacher and the student.

The effect of supervising graduate research is even more pronounced upon the teacher. In this activity he sets himself in the position of an expert in the field and opens his breadth and depth of knowledge to the penetrating scrutiny of the graduate student. He must not only be well versed in the literature and knowledge of his field but he must also be able to critically evaluate what he knows. In conducting graduate research a knowledge of the gaps in the scientific literature is extremely important. In all of this he is stimulated by the graduate student's intensive search for a solution to his dis-

sertation problem. It is axiomatic that the graduate teacher benefits to a degree commensurable with the students' gain in knowledge. Probably graduate research with creative students is the most stimulating experience that it is the teacher's lot to possess.

The conducting of graduate seminars is also a valuable teaching experience. Here, perhaps, more than anywhere else the graduate teacher is forced to think "on his feet" at the limit of his knowledge. Seminars which occasionally bring in the foremost engineers and scientists in the field are also extremely valuable. All graduate teachers sooner or later encourage their undergraduate students to attend advanced seminars. Even though the subject may be "pitched" at a level which is too advanced for the undergraduate, an occasional exposure has benefits. It opens the eyes of the undergraduate to what lies ahead of his present studies and gives him a better perspective of the future.

Powerful Stimulus

To sum up this paper it can safely be stated that graduate programs offer a powerful stimulus for improving undergraduate curricula and teaching. The present trend towards more emphasis on graduate education cannot help but portend a greatly improved undergraduate program for the future.

Mathematics Division of The American Society for Engineering Education

Annual Meeting Pennsylvania State University

June 20-24, 1955

The Mathematics Division of the American Society for Engineering Education will meet at the Pennsylvania State University, University Park, Pennsylvania, June 20–24, 1955.

On June 20 Dr. Abe Pepinsky, Chief of Psychological Services, Norristown State Hospital, Norristown, Pa., will address the luncheon meeting on the relation of *Fourier Series and Timbre.* During the afternoon session D. L. Thomsen, International Business Machines Corp., will answer the question *Can Computers Speak for Themselves?* Then Ray Pepinsky, Pennsylvania State University, will discuss the X–RAC and S–FAC and give a demonstration of these computers.

On the following afternoon, June 21, in a conference and panel discussion on Quality Control the participants will be: Ellis R. Ott, Rutgers University, The State University of New Jersey, *Statistics in Engineering and Engineering Education: Basic Concepts;* Enoch B. Ferrell, Bell Telephone Laboratories, *Statistical Applications: Electronics;* Frank Wehrfrite, Esso Std. Oil Co., *Statistical Applications: Chemical;* Milton E. Terry, Bell Telephone Laboratories, *Statistical Applications: Research.*

Dr. R. S. Burington, Navy Department, will give his address as retiring chairman on *For what Careers should we Train Mathematicians?,* June 22. This will be followed by a conference on Linear Programming: A. W. Tucker, Princeton University, *Mathematics of Linear Programming;* M. M. Flood, Columbia University, *Applications of Linear Programming:* Alan Hoffman, Bureau of Standards, *Computing Linear Programs.*

On Thursday, June 23, the mathematics part of a joint conference with the Educational Methods Division and the Physics Division will include: George W. Patterson, Burroughs Adding Machine Co., *Abstract Mathematics and the Design of Networks,* and Robert J. Wisner, Haverford College, *Some Remarks on the Theory of Matrices and Their Application to Engineering Problems.*

Requests for housing should be addressed to John B. Nesbitt, Chairman, ASEE Housing Committee, 208 Main Engineering Building, University Park, Pennsylvania.

C. O. Oakley, *Chairman,*
ASEE Mathematics Division

Nuclear Education for Engineers*

By A. M. ANDERSON

Manager, Engineering Training and Education, Engineering Personnel Department, Engineering Services Division, General Electric Company

Introduction

On May 24, 1954, Mr. F. K. McCune, General Manager, Atomic Products Division, General Electric Company, was talking on Private Reactor Development at an Atomic Industrial Forum Panel. During his discussion, he outlined succinctly the position of the General Electric Company in the atomic power area by four statements:

"First—we at General Electric believe that electric companies will own and operate a number of atomic power plants within the next 10 years.
"Second—we believe some of these will be full scale and they will generate electricity at competitive costs, possibly within five, certainly within ten, years.
"Third—we believe that this will be accomplished without continued government subsidy for production plant construction or operation, and that government supplied fuel will be priced at cost of production levels.
"Fourth—we believe that two nuclear reactors best suited for earliest and most effective competition with conventional fuel plants in this country are (a) the light water moderated and cooled boiling reactor, and (b) the graphite moderated water cooled reactor. These, we think, hold the greatest promise in the years ahead."

From your point of view, two pieces of information probably result from this statement, first, this is going to be a big business; and second, an inference, engineers will be needed so we had better get busy producing them. In addition, this might be accepted as a signal to direct some of the educational processes along certain channels, the channels of teaching the technology of water-cooled reactors, and if the prognoses are correct this possible educational system might produce some engineers reasonably proficient in these areas. However, before we accept this solution, let's take a tour behind the scenes and gather some more data, which will help guide the future direction of our plans. Here we might be interested in one basic issue which will provide a wealth of information. If, somehow, we could determine what technical problems are confronting the engineer working in this atomic power business, we might then infer what types of education would help him in his work. If secondarily we could ask him what he perceived to be his difficulties in understanding, we might have a measure of sorts of the validity of our inference. Then having these data we would be in an excellent position to chart a course of action for engineering education.

To take this tour we must be careful to avoid classified data, and to insure that this is properly done, I have selected problems which have previously been stated publicly, but have been careful to select those which are truly representative of the development and design functions. I have purposely omitted problems of an equipment manufacturing and marketing nature, not because they are unimportant, but because an understanding of the issues in the first two cases yields a large measure of understanding of the

* Presented at the Upper New York Section, Annual Meeting of ASEE, October 23, 1954.

last two cases. These problems, five in number, are grossly stated and represent five large areas of technical understanding in this business.

1. A pile is a massive structure having many materials with dissimilar thermal expansion coefficients. Structurally, the parts must remain intact and care must be taken in certain sections to insure that relative dimensions remain fairly stationary over wide ranges of operating conditions, as for instance the coolant passages. The heat generation per unit volume is ideally quite high, not only because this leads to fewer pounds of core and internal structure per kilowatt of capacity, but because shielding must be wrapped around the whole structure. The stress analyst must, therefore, know where and how the heat is generated, what the limits and rates of change of operating conditions are, what the allowable stresses are in light of the high internal radiation densities, the influence of coolant and other physical conditions on corrosion, and then he is on the threshold of being in a position to apply his understanding of the laws of elasticity to his problem. As might be expected, his analyses and postulates may well influence the coolant system and complete structural system, hence he must be cognizant of the heat transfer and, to a certain extent, the complete design considerations.

2. Some materials absorb radiation, others pass it through to a large degree, based on their "cross-section for neutron capture." This property is a function of the nuclear arrangement of an element and involves the metallurgist—and perhaps the metallurgical engineer—in the physics of metal structure. Selections of materials must sometimes reckon first with the required nuclear properties and then consider the usual criteria of strength, elasticity, and corrosion resistance. In the latter respects, the problems are like those of other process industries, but this unconventional approach often restricts the choice of materials and consequently freedom of design.

In some instances, materials of extreme purity are required, far beyond today's commercial standards. Since some of these needs appear basic rather than temporary, entirely new standards of production and of acceptance testing are arising in certain fields. Closely related is the problem of getting such high quality without excessive cost premiums. Ultimately the effect could be to raise the standards in several fields of materials engineering, with benefits not limited to the nuclear industry.

The metallurgist also faces the problems of technique in his determination of properties of metals. A radioactive material may require remote handling for physical testing, as well as for metallographic polishing and etching. If photographed directly, it will cloud the film. New techniques must be developed. And the metallurgist too must inquire whether intense bombardment will affect the properties of materials. Here the practice must be linked to studies in physics of the solid state. In effect, the engineering is related to scientific findings which are just now emerging.

3. The chemical engineer uses the familiar techniques—distillation, absorption, extraction and other unit processes. But here he deals with extremely precise processes in which the yield may be a very small part of the original input, and therefore complete reactions and exact proportions become unusually important. In separating fissionable U-235 from the more stable U-238, only 0.7% of the original material is even available as potential nuclear fuel.

To complicate the task, the design and operation of any process must be such that absolutely no source or fissionable material is lost. For these items, accountability from start to finish must be complete. This is the law, and its purpose is not only to forestall unauthorized use of these valuable elements, but to prevent the personal hazards of letting radioactive material be mislaid or lost. Some isotopes remain strongly radioactive

for thousands of years, so absolute material control must be envisioned in design and operation.

It is not by accident that radiation damage to personnel is almost unknown and that the incidence of even the common industrial accidents is extremely low. Considerations of safety are paramount in all research, process designs and operations.

The design of equipment often contemplates that both control and maintenance be conducted remotely. Instrumentation and control methods must be workable and accurate in fields of radiation, and optical developments may be required where direct viewing is not feasible. Aside from the expense and embarrassment which always accompany "second guessing" after a plant is in operation, access for changes is difficult, sometimes impossible, where high levels of radioactivity occur.

Again, rates of process reactions and of corrosion may be influenced by radiation, and the data will not necessarily follow patterns established for stable elements. Even a heat balance might have to reflect the energy emission of some short-lived elements, here today but changing. So the chemical engineer likewise encounters problems outside his usual fields, and will have need to branch out.

4. The heat transfer analyst encounters odd physical configurations and sometimes deals with extremely high heat flow intensities. To analyze what is possible, he has to resort to basic properties of fluids—specific heat, conductivity, viscosity, density—to arrive at proportions not usually found in the literature. As always where one depends on high rates of heat transfer, there is the need for maintaining them, month after month, against surface deposits which might soon reduce the transfer rates. Here the problem leads into one of extreme chemical purification to avoid such deposits. Our analyst must consider also whether the heat transfer fluid itself will absorb enough radioactivity to require a second transfer medium before this special aspect can be dismissed.

5. The basic proportions, or lattice structure, of a pile are always a subject for further study, i.e., the arrangement of uranium fuel elements, coolant paths, radiation-absorbing materials and controls. If one would establish an improvement here, he must tackle first a problem of nuclear physics—the generation and conservation of the flow of neutrons. But the proportions established in the design must also allow for well-placed and sure-fire controls, and must provide space for elements of sturdy mechanical design and reasonable access, as well as for adequate flow of coolant. All this becomes a problem for a team combining the talents of the physicist and those of the design engineer. And if the engineer is well-grounded technically, this association plus further study will enable him to understand the nuclear phenomena which underlie his design.

6. Seldom has a new field of scientific and engineering effort resulted so quickly in an enormous capital investment. The present plants in aggregate have cost billions and there is some prospect of further major expansion. The very first facilities, built without pilot plant or semi-works experience, were successful due to sound analysis, creative and thorough design. The same kinds of continuing effort have brought major improvements and economies in both the original and the more recent plants.

Beyond the present accomplishments, there is, nevertheless, a major opportunity for systematic engineering—economic analysis of existing plants and practices and of economic interpretation of technical developments which will lead to profitable peace-time uses. Here the methods of analysis are much like those of other industries, but the problems often involve technologies that are new. There is little experience as a guide.

7. The power level of a reactor must be controlled quite precisely, since by its very nature the reactor tends to increase

its reaction rate without limit or decrease toward zero. Fortunately, these rates of change are not too rapid except in very extreme situations so the gross reaction rate is physically controllable. In no sense, however, must this be construed to indicate that the man who develops the controls has a simple task. First, he must determine reliable means of detecting reaction rate and its rate of change. Then he must construct a system which will alter these rates, possibly by inserting or retracting neutron absorbing material; and finally he must provide some sort of safety system to produce an overall fail-safe plant.

Present Educational Patterns

If we examine present undergraduate curricula and attempt to determine the utility in the nuclear engineering field of the understanding gained, we might reach this conclusion. Each kind of engineer that we now produce will find a challenging job for his special talents or at least for certain major parts of his understanding in this new area. However, from some of these problem descriptions, it is apparent that certain changes are in order principally because of the obvious breadth and slightly non-conventional aspects of these situations which our young B.S. engineers face.

The two changes that seem paramount in importance are:

1. Increase the scope or breadth of understanding of the young engineer in the classical fields.
2. Improve his understanding of the principles of the structure of matter and behavior of radiation.

Note that I have very carefully used the word understanding and not the word knowledge, a distinction I would like to emphasize in this manner. If one observes a series of isolated events and duly records the impression in his memory, then it is fair to say that he has knowledge of these events. If, in addition to this, he is able to postulate a principle which under differing conditions of application logically infers the occurrence of the isolated events, then he has the beginnings of understanding in this area. As he continues this course of action and builds a consistent and well integrated body of principles, his understanding becomes more fundamental. This procedure is by no means a mechanistic procedure, but it requires creative talents of the highest order, and it is this understanding of principles which is our goal in education.

Here it becomes apparent that the two changes proposed will probably produce some time conflicts in present curricula, but in a few instances, at least, with which I am familiar, some courses with the objective of presenting present engineering practices could well be replaced with courses of different objectives. For instance, attempts at presenting current practice are fraught with the dangers that the end result of a deductive process becomes the sole objective, and that the system deteriorates into a memorization of specifics. This should in no sense be construed to indicate that realism should be overlooked in the process of learning, but it does mean that more freedom must be permitted the student in defining the boundaries of his deductions. Also as a corollary, we should encourage the student to define for himself the precise nature of a general problem, for in this manner he obtains practice in the inductive processes so important to the creative mind. In a very real sense, then, I am saying that the premium is paid for the young B.S. college graduate with a high thinking quality and a sound groundwork of understanding of physical principles, and with these characteristics the specific knowledge required on his industrial assignment can be readily learned during his career.

The question might next arise, "but when does a man start to become more specific in his choice of physical fields of understanding, because he obviously cannot continue forever in the direction of

learning everything about everything." It appears to me that a convenient time to start this specialization, or preferably a narrowing of the scope of study, is at the M.S. level, and it is probably quite appropriate to continue this procedure through the doctorate level. Again, however, there should be close attention paid to the breadth of the area of understanding outlined as the goal of this highest academic level, and, therefore, to the rate of narrowing of the scope from the B.S. level upward. This is becoming particularly true in the nuclear engineering field as the density of attention devoted to problems shifts away from the pure research toward an applied research and development category, where the breadth of the problem increases as indicated in the earlier problem descriptions.

Then, a specific recommendation would be:

1. Do not teach nuclear engineering specifically, as an undergraduate curriculum.
2. Lay the foundations upon which a young man can build a nuclear engineering career, either through going directly to work or continuing his study.
3. As a part of this foundation, increase the emphasis on the structure of matter and on basic principles, and decrease the emphasis on practice.
4. Examine carefully the scope outlined as an objective at the B.S. level, and the scope for the Ph.D.

Conclusions

I would like to present, in conclusion, two points which will serve to strengthen these recommendations. By definition, progress means change, and the prudent educator, therefore, moulds his student in the manner which yields the highest probability that not only will he survive the change, but he will be able to take the leadership in effecting changes. This necessitates teaching those things which are most stable and enduring in such a manner that creative talents necessary for stimulating evolution are not restricted.

As further evidence of this point, taken directly from the nuclear energy field, consider the problem of separating fissionable material from fission products. A very fine course in this separations technology could be prepared and it might, in fact, be useful. However, the man we need is the one who creates a novel and far simpler method of separation, and I have no assurance that this will even remotely resemble our present practice.

As a final potentiality, the man who would really do us the most good might find a method of combining hydrogen or other light nuclei in a manner which yields electrical energy directly. Perhaps it's only an idle day dream, but if it ever does occur, we will then need educated engineers to exploit this new area to its utmost.

Objective Testing in Mechanics at the Michigan College of Mining and Technology 1948-1954

By C. J. PRATT

Associate Professor of Physics, Michigan College of Mining and Technology

Immediately following the second World War departments of instruction on many campuses were confronted with the problem of instructing and assigning grades to a greatly expanded student body. In most cases there were several sections of each course being taught at different hours by different staff members.

The problem of how to assign grades equitably is of long standing. This report is a record of how one department on one campus has attempted to solve it. The impetus provided by the great influx of students during the years 1946–1948 gave rise to an achievement testing program in an attempt to make sure that students doing the same level of work would receive the same grade for the course though they might be in different sections and under different instructors. Beginning with the fall term of 1948 all grades assigned in general physics and engineering mechanics in this College have been based exclusively on the results of objective testing.

The subject matter included in the courses designated as "Mechanics" in this article is the mechanics section of general physics and two or three terms of engineering mechanics, depending on the course of study being pursued by the student concerned. All of these subjects are currently taught in the Physics Department of this College. Each course is one of the prerequisites of its sequel.

From the beginning of this testing program the major emphasis has been placed on the construction of adequate test items since no measuring instrument is better than the parts of which it is composed. For our purposes the multiple-choice item has proved superior to the other commonly used types. At first, five choice items were constructed, but recently the number of choices has been reduced to four, e.g.,

> A slender rod is six feet long and weighs 128 lb. Its moment of inertia about an axis normal to the rod and passing through the rod two feet from one end, expressed in slug ft^2, is:
>
> a: 16 b: 12 c: 28 d: 37

If it is desired only that the student show his ability to use the transfer formula for moments of inertia in the problem shown above, he could be given the expression for the moment of inertia of the rod about the transverse axis through its center of gravity.

The construction of an item in which the distractors will appear to be feasible to students who do not fully understand the principles involved is a difficult operation. Much practice in item construction improves the test builder's skill in designing items which will discriminate between those who can and those who cannot perform the important operations in scientific and engineering problems.

The first step in item construction is to outline the aims and content of the area to be tested. The individual items should be referred to other staff members teaching the same subject for a check on

the validity and accuracy of statement and answer. Student reaction is a good indication of the "face validity" of the item.

It has been found that from fifteen to twenty-five items will keep the best student busy for an hour, depending on the difficulty of the items. A two-hour final examination may have from thirty-five to sixty items. In this way adequate sampling of the principles and techniques of the course has been made possible.

The fact that a test may be valid does not insure that it will discriminate among the achievements of the good and poor students. The best possible item is one that the better students will get right and the poorer ones will miss. Because of lack of personnel and mechanical equipment, only about ten percent of the items on file locally have been so analyzed.

One of the more difficult operations in test building is to construct equally difficult, but different, forms of the same quiz to be given to sections meeting at different hours. If it is found that the level of difficulty does apparently differ from form to form, it is possible to run separate frequency distributions for the different forms. At Michigan Tech all mechanics sections take the same two-hour final examination at the same hour to assure that the same instrument is used in measuring all the students.

New quizzes and final examinations are built each term, and the items are mounted on 5" × 8" cards for filing. A library of quiz items collected over a number of years makes test construction easier and improves the quality of the product as time goes on. Copies of old quizzes and final examinations together with their score distributions are kept on file for subsequent analysis and possible reuse in special cases.

In a typical test booklet the printed answer sheet constitutes the last page. This arrangement reduces the opportunity of transferring unauthorized information from student to student. Computation sheets and scrap paper are collected with the booklets. No account is taken of work leading to the answer to each item in a test. It is believed that the instructor has had plenty of opportunity to observe the students' performance during the term while they have been under instruction. It is hoped that the "small errors" have been eliminated during periods of instruction so that he can be measured on the basis of his ability to solve the problem completely and correctly at the time he is tested.

Template is Used

In correcting the answer sheet a template is used to aid in counting the number of correct responses. Blank spaces as seen through the holes of the template are marked in red, and the template is then removed. The number of wrong responses is then counted and divided by three (the number of choices less one) to serve as a correction for guessing to be applied to the number of correct responses. This operation yields the "earned score" or the number of items the student KNEW how to work. Expressed as a mathematical equation:

$$S = R - \frac{W}{N - 1}$$

in which S is the earned score, R the number right, W the number wrong, and N the number of answer choices for the item.

For a fifteen-item quiz the value of S has a possible range from negative five to positive fifteen, where R and W can vary from zero to fifteen and N is four. A sample quiz may yield an actual distribution of earned scores from zero, and occasionally lower, to a positive value equal to the number of items on the quiz, depending on the difficulty of the quiz and the level of achievement of the students being tested.

During a twelve-week term it is customary to give three or four unit quizzes and a final examination in a given course. This poses a question relative to the com-

bination of the scores earned on the separate tests. Each earned score actually represents the numerator of a fraction, the denominator of which is the maximum score on that test. Since it is not permissible to add fractions with different denominators as they stand, the next step was to devise a method of expressing the earned scores from different quizzes in terms of a new unit so that their combination would not violate the rules of mathematics.

As an example, let us consider any frequency distribution of earned scores for 276 students. One solution to the problem would be the following sequence of computations:

1. The mean earned score;
2. The mean deviation (md) for each earned score;
3. The standard deviation (s) of the distribution; $s = \sqrt{\frac{\Sigma (md)^2}{N}}$
4. The standard score (z) for each earned score; $z = \frac{md}{s}$
5. The T-score for each earned score. $T = 10z + 50$

Regardless of the mean or range of the earned scores, we thus have a measure of the student's achievement expressed in terms of the standard deviation of the distribution of these earned scores. The relative weight to be assessed to each test is entirely in the hands of the staff members concerned with the task.

On the basis of past observations for groups of this size the range of z-scores would be from minus 2.5 to plus 2.5, or from 2.5 standard deviations below the mean to a like amount above. The reason for translating the z-scores into T-scores is to eliminate the negative numbers and to change the decimal fractions into integers. Thus a corresponding range of T-scores would be from 25 to 75. The mean earned score of any distribution would have a T-score of fifty regardless of its absolute value.

A simpler alternative operation is the determination of "normalized T-scores" obtained in the following manner. The actual frequency distribution of the earned scores for the 276 students on a recent quiz is shown below.

Score S	Freq. f	Σf_{up}	P	T
18	10	276	98.2	71
17	22	266	92.5	64
16	14	244	85.9	61
15	30	230	77.9	58
14	37	200	65.8	54
13	33	163	53.1	51
12	21	130	43.4	48
11	20	109	35.9	46
10	19	89	28.8	44
9	23	70	21.2	42
8	9	47	15.4	40
7	9	38	12.2	38
6	14	29	8.0	36
5	3	15	4.9	34
4	3	12	3.8	32
3	5	9	2.4	30
2	4	4	0.7	26

Step 1. Find the subtotal of the frequencies up from the bottom for each earned score (Σf_{up}).

Step 2. Compute the percentile (P) for each earned score, where

$$P = \frac{1}{N}\left(\Sigma f_{up} + \frac{f}{2}\right).$$

Step 3. For each percentile there is a normalized T-score which is read directly from a table of T-scores (see end of article).

Sample computation: $P = \frac{1}{276}\left(200 + \frac{30}{2}\right) = 0.779$

The sample computation indicates that a student with an earned score of 15 has ranked better than or equal to 77.9% of the 276 students who took this quiz. From a table showing areas under the probability curve it appears that 77.9% of the total number of cases will lie to the left of a vertical line 0.8 standard deviation above the mean. Hence, a percentile of 77.9 corresponds to a normalized T-score of 58 and for every other percentile there is a unique normalized T-score. Such a conversion table is given at the end of this article.

After each quiz the student is given his percentile for that unit of work which fixes his rank according to achievement in the group as a whole, which is all we try to do. The corresponding T-score goes into the class record to be combined with others, on which his final grade for the course is determined.

When several tests are given over a period of time and the corresponding T-scores are added or averaged, there results a "regression" toward the mean. It is therefore customary to spread either the sum or the average of the unit quiz T-scores as a new frequency distribution to determine normalized T-scores corresponding to these sums or averages as the case may be. This effectively removes the regression and gives each student a single T-score (T_q) based on the several quizzes which can be combined directly with the T-score earned on the final examination (T_f) in whatever ratio seems advisable under the circumstances. Locally the final examination counts 50% toward the final grade in the course.

In this way we have arrived at a single score which is a measure of the student's achievement by which he can be ranked with his fellows with complete objectivity. How the final grades are assigned rests with the staff members who have that responsibility, but this method makes it possible to do a competent job in that operation.

Collateral Benefits

Collateral benefits are many, of which two are outstanding. First, the instructor spends all but five or six hours a term teaching the course instead of continually concerning himself with the problem of evaluating the student's progress. Second, the analysis of the course content required for an adequate testing program requires a continuing effort toward its improvement.

During the seven-year period covered by this study, 1663 students have successfully completed the mechanics sequence at this College. Of these, 1337 have graduated, 137 have left school without graduating, and 191 are still in school on this campus.

Positive coefficients of correlation ranging from 0.6 to 0.8 between mechanics grades and all-college averages indicate that this type of testing program provides a good indicator of future academic success in college.

P	*T*	*P*	*T*	*P*	*T*	*P*	*T*
99.9	79	91.2–92.6	64	44.3–47.9	49	4.9–5.9	34
99.8	78	89.3–91.1	63	40.8–44.2	48	4.0–4.8	33
99.7	77	87.3–89.2	62	36.6–40.7	47	3.3–3.9	32
99.6	76	85.6–87.2	61	32.6–36.5	46	2.5–3.2	31
99.4–99.5	75	83.2–85.5	60	29.0–32.5	45	2.0–2.4	30
99.2–99.3	74	80.3–83.1	59	26.0–28.9	44	1.6–1.9	29
98.9–99.1	73	77.9–80.2	58	22.2–25.9	43	1.2–1.5	28
98.5–98.8	72	74.1–77.8	57	19.8–22.1	42	0.9–1.1	27
98.1–98.4	71	71.1–74.0	56	16.9–19.7	41	0.7–0.8	26
97.6–98.0	70	67.5–71.0	55	14.5–16.8	40	0.5–0.6	25
96.8–97.5	69	63.5–67.4	54	12.8–14.4	39	0.4	24
96.1–96.7	68	59.3–63.4	53	10.8–12.7	38	0.3	23
95.2–96.0	67	55.8–59.2	52	8.9–10.7	37	0.2	22
94.1–95.1	66	52.1–55.7	51	7.4– 8.8	36	0.1	21
92.7–94.0	65	48.0–52.0	50	6.0– 7.3	35		

• • • YET-ITUDES*

• *yelps and helps for the young engineering teacher*

Contributed by CYET
PHIL WEINBERG, *Chairman*
University of Utah

LEE HARRISBERGER
Editor of YET-itudes
N. C. State College

"Industrialitis?"

This is the season of the year that gives the wives of young engineering teachers a hard time. This is the month when the recruiters make their salary offers, the senior gets signed up for his first job, and the students ask the faculty whether to work for this company at "four and a quarter" or take that job for "four hundred."

This is the time when the YET goes home to "la" spouse and raves and roars about how his students are getting starting offers that often equal or better his own teaching salary. He bellows about the inequities of life; he figures he ought to be out there designing rockets, or something; and teaching ought to be retired to instead of from; etc., etc.

These wife-directed verbal epics are the manifestations of an occupational disease of YETs called "Industrialitis." The symptoms are a severe pain in the paycheck complicated by "thwartitis," "left-out-ishness," deflated ego, and "selfpityosis." All are brought about by a drastic exposure during the spring months to a concentrated atmosphere of industrial recruiting.

There isn't a YET in the business who doesn't catch a case of "Industrialitis" to some degree every spring. Unfortunately, there are too many YETs each year who do not survive the disease and fail to return to teaching in September.

This occupational hazard has cut into the YET ranks heavily in the past few years. As a result "extensive" research has been undertaken to determine the susceptibilities and immunities to the disease as well as effective therapeutic devices which can be used to combat it, once it is discovered.

It was discovered that YETs suffering from a deficiency of surplus operating capital were extremely susceptible and virtually impossible to cure. It was generally noted that those persons with the greatest "capital pains" failed to respond to any other stimulant.

In general the studies show that a generous income is the best immunity to "Industrialitis." However, since all YETs suffer some degree of austerity, all catch the disease. Those who survive, it was discovered, generally do so in spite of an anemic checkbook. This has led researchers to investigate the other factors which are contributing to recovery.

It was found that the perennial YET is a particular "breed-of-cat." He puts his professional values in several baskets and considers each as singularly important as the other. Thus, when the disease catches him he soon recovers on the strength of each of the factors. It's pretty hard to give up six "good deals" for one—even if the one is "mo dollah."

Since so many YETs find it increasingly

difficult to fight off "Industrialitis" each spring, the investigating committee recommends the following "home remedies" for building up the strength.

Dose: Frequent consideration until pain is relieved.

- How about the terrific personal satisfaction in having a part in the intellectual growth of capable students, in being able to guide a student toward enlightment?
- Think of the unlimited challenge to devise new and better techniques for motivating and encouraging a student, presenting a subject or developing a student's creativity. We haven't even started yet!
- Where else can you enjoy the freedom of professional accomplishment? There's the freedom to develop a consulting practice,* engage in research unlimited,* develop new courses, write books,* accept foreign exchange fellowships, work at a variety of industrial jobs,* take advance courses, attend seminars, participate actively in professional societies and write technical articles for current publications. Where can a man have the opportunity to choose within such a scope of intellectual activity, to specialize or diversify as he chooses?
- Where else can a person enjoy the freedom from regimentation? There are no time cards, no "eight to five," no half hour lunch period. If you have to go to the bank—you go to the bank! If you have to baby sit during the day—you baby sit!
- How about vacations? Do you think you could easily trade three and one-half months "off" in the summer, plus two weeks for Christmas and a week in the spring for just two weeks of vacation "sometime during the year"?
- Where else can you enjoy the fellowship of men of intellect in all areas of study, the breadth of cultural and social activity of campus life?

By golly, this engineering teaching sounds like a good deal, doesn't it? Don't let "Industrialitis" give you "shrinkage of the perspective." We certainly hope you'll all be back in the fall.—L. H.

* (There's "gravy" money here.)

Here's your YET-itude for May: "Don't give up, YET! You never had it so good!"

ECPD Publishes Papers on Orientation and Training in Industry

A group of four papers discussing orientation and training in modern industry are now available in a publication of the proceedings of the 22nd Annual Meeting of the Engineers' Council for Professional Development, held recently in Cincinnati, Ohio. The papers were presented by representatives of four industrial firms which have been participating in the pilot study of the ECPD program known as "The First Five Years of Professional Development."

The publication includes a copy of the brochure describing the program for young graduate engineers during the "First Five Years" and a copy of the brochure reporting on "The Community Project in Professional Development" which has been studied recently in Cincinnati. Copies of the publication are available by addressing ECPD Committee on Professional Training, 322 Baldwin Hall, Cincinnati 21, Ohio.

Summary of ECAC Conference on International Relations*

Introduction

As a nation we cannot live by ourselves. The growing awareness of our interdependence with the countries about us has recently been translated into action in many ways. One such manifestation is the increased emphasis upon programs aimed at helping our friends through education in the broadest sense. Long experience has shown our educators that mere "book learning" will not satisfy the need of those who come to us for help. They need and want not only an academic education, but the kind of practical work experience in our shops and factories and offices which will allow them to return to their countries and effectively attack the problems faced there.

The following is a summary of the ECAC Conference on International Relations held in Urbana, Illinois on June 17, 1954, as a part of the 62nd Annual Meeting of the American Society for Engineering Education. The panel was under the Chairmanship of Dean Francis M. Dawson of the State University of Iowa and had as its announced theme: *Encouragement and Development of Opportunities for Work Experience for Foreign Students.* The speakers were chosen with the view of bringing together men with different outlooks on this subject. The points of view and the speakers representing them were:

1. The Colleges. Arthur Hamilton, Dean, University of Illinois.
2. Sales. H. T. Maser, Foreign Student Director, International General Electric Company, New York 22, N. Y.
3. Government. Joseph Cushman, Division of Immigration and Naturalization, Chicago.
4. Manufacturer. W. J. Holmes, Allis Chalmers Mfg. Company, Milwaukee, Wisconsin.
5. Foreign Operations Administration. Fred K. Bollman, Development and Management Section and Leeds Gulick, Works Study Program.

H. L. Hazen, Dean of the Graduate School, Massachusetts Institute of Technology and Chairman of the International Relations Committee of the Society, was a prime mover in the organizing of this conference.

The entire forum was recorded on tape and later transcribed. However, as the program lasted well over two hours, condensation proved necessary. The following is an attempt to summarize the salient points of the proceedings in convenient form.

The following passage from a letter written by Dawson to Hazen was offered as a keynote for the afternoon's discussion:

"It should be emphasized that foreign students have to learn not the American way of doing things with big machinery which is not available to them in their own country. They need to learn, rather, about the thoroughness and meticulous care with which engineers in this country plan all operations in order to minimize waste and make for increased efficiency. Examples of this are production methods and quality control. I wish to point out from experience that it is quite silly to have men trained in the use of heavy earth-moving machinery, for example, when the real necessity is for

*Held at the Annual Meeting of ASEE, University of Illinois, June 17, 1954.

thorough planning and careful detail so that work in their own countries may be efficiently and effectively carried out."

Dawson extended this by remarking that engineers being trained for work in the so-called underdeveloped countries need less emphasis on the purely theoretical or scientific side of engineering and more on the "know-it-yourself" type of training so that when they go back home they are able to show the workers and others how "things should be done."

The foreign student needs also to learn something of the "dignity of common labor from the American industrial system in which no sharp distinction between management and labor exists," Dawson urged. "Something must be done," he went on, "to make some of these foreign students feel that they would not be losing caste if they got their hands dirty."

Dawson then introduced Dean Hamilton of the University of Illinois, pointing out that he was in charge of foreign students' relations at Illinois and particularly qualified to speak on the problem by virtue of the fact that his school is presently serving 550 foreign students, approximately 350 of whom are engineers.

Dean Hamilton:

Dean Hamilton began by crediting his colleagues with doing things for the foreign students while he failed to do as much for them as he would like. The biggest thing that can be done for these students, he went on, is not what can be done for them in college, but "what they can get from practical training outside after finishing theoretical training in college."

Quite good theoretical training is available almost everywhere in the world, but in many places laboratory facilities are either poor or completely lacking. He cited the example of a small university in Guatemala City where he had seen the laboratory equipment for nine scientific departments stored in a safe approximately six feet by six feet by four feet. He cited other instances in support of the general point that many countries are woefully lacking in the facilities needed "to give adequate preparation from the know-how angle."

Hamilton agreed with the Chairman that it would be well if the concept of work as an "ennobling process" could be more widely inculcated, but he expressed serious doubts that even so "efficient a country" as the U. S. could break down the "prejudice of ages" in six months or even a year and a half. To exemplify the nature of the problem, Hamilton told of a student, a foreign national, who had come to him much disturbed because he was unable to find a suitable body servant. This man professed never to have dressed or undressed without the aid of a servant. How long, asked Hamilton rhetorically, will it take to change the viewpoint of an individual with that kind of background?

The Illinois Dean protested that the one-and-one half year training program for foreign students graduating in this country is inadequate. It does not give them time enough to get the kind of industrial experience they need. Moreover, the shortness of the period operates against the students' chances for finding jobs, as most industries feel that in an 18-month period they have to put more into a man than they can get back.

The problem created by the short time allotted foreign students on a student visa is aggravated by the fact that people who come here from abroad under exchange visitor visas may stay for three or four years. "It seems to me," urged Hamilton, "that as this program is designed to get us friends . . . something must be done about bringing these two kinds of visas together and giving them all the same privileges."

Though not professing to know exactly how long a time would be needed to give foreign graduates from our schools adequate industrial experience, Hamilton insisted that a year and a half is too little. He concluded by urging Immigration to lengthen the work period for students

and to equalize the period for all classes of visitors.

Mr. Maser:

The second speaker introduced by the Chairman was Mr. Maser, Foreign Student Director of The International General Electric Company. Maser began his talk by recalling "enchanting tales in ancient history, telling how pioneers travelled long and weary miles to pray for the things not prevalent in their own country." With such pilgrimages began the exchange of goods and knowledge between countries. Such exchange, he declared, is beneficial, and the need for it continues to the present.

Modern business serves principally three major groups: its customers, its employees, and its stockholders. The foreign operations of a business help all three, not only by increasing efficiency and lowering costs at home, but by decreasing disease and poverty (the seeds of war) abroad.

For over half a century business leaders have been training people abroad. This was necessary if foreign operations were to continue and expand. The companies simply saw the need, selected the people, and trained them—some as foreign representatives, some as dealers, some as customers, and still others to help in foreign industrialization. Some of this training was done in the plants in this country; much of it was done directly in the foreign field.

"Companies in foreign trade have come and gone," Maser continued, "but despite these fluctuations, people from foreign countries continue to be trained by companies here." He reported that a questionnaire, mailed by him to 200 companies, had to date elicited 90 responses. Of the 90 firms replying, 67 train foreign students as against 23 which do not. Fifty-eight of the firms which replied filled out the questionnaire in full. Their responses indicated that traing was being offered in a wide variety of work, including all branches of engineering; that the training varied in length but was mostly for about one year; and that 50 of the 58 programs had been started within the last 10 years. The various programs upon which information was obtained presently include 156 men from 43 countries. Maser estimated that these 58 companies had trained 2900 men from 65 foreign countries at a cost, in living allowances to the men alone, of over five million dollars.

In speculating as to whether these data could be extended to industry as a whole, Maser conjectured that the resulting figures would be higher than would appear logical. While making no claim that either his own company or industry generally was engaged in this work from philanthropic motives, he concluded with the following comment on his own company's activities in this area:

"We have had foreign students in the General Electric Company since 1893. During that time we have brought in about 1700 foreign students. We feel that it has been of great benefit to us. We feel also that it has been of great benefit in cementing relations between our country and nations abroad. And we feel that our program has been helpful in creating good relations internationally."

Mr. Cushman:

Mr. Cushman, described by the Chairman as a representative of "the government side," pointed out that as Deputy District Director of Immigration and Naturalization for the Chicago district it was his duty to help administer the Immigration and Naturalization law for that area. This work involves a great many categories of people, only one of which is the "foreign student." The law, Cushman went on, defines the foreign student as "an alien having residence in a foreign country from which he has no intention of abandoning, who is a bona fide student qualified to pursue a full course of study and who seeks to enter the United States temporarily and solely for the purpose of pursuing such a course of study." The job of his office Cushman

described as that of seeing "that a foreign visitor maintains the status for which he was admitted to the U. S. and departs from the U. S. when his objective has been gained and his visit completed."

Speaking of the frequent requests which come to him for help in finding some means by which foreign students who have completed their college training and 18-months practical work period may stay in this country, Cushman pointed out that such help serves to defeat the purpose for which the educational program was designed and to transform it into a sort of immigrant-recruiting program. However, the possibility of a foreign student's having his status changed to that of an immigrant does exist if his country's quota is not oversubscribed. But each time this is done, warned the Immigration Department official, the purpose of the program —that of returning trained men to areas where they are needed—is frustrated.

Addressing himself to the question of how long a foreign student may stay before he ceases to be a student, Cushman said: "Frankly, he ceases to be a bona fide student when he loses his desire to complete his objective and return to his homeland." The regulations now read 18 months, he went on, and must, as long as they so read, be enforced. The McCarran Act was designed to prevent people from entering the U. S. under one status and remaining under some other. Emphasizing the magnitude of the problem, Cushman pointed out that people come into the U. S. at the rate of 170 million entries a year.

Cushman then urged that the schools explore and define exactly what the needs are for practical training time and then work with the government to get the kind of regulations they need. At the same time he called attention to two types of complaints with respect to foreign students that come to his office: 1) American students complain that on-campus and off-campus employment is reserved for foreign students, forcing the native student to look far afield for work. 2) The foreign student in practical work is accused of taking employment from the native worker. This latter complaint, Cushman pointed out, would reach greater proportions if economic conditions were to get worse. "When a man is hurt," Cushman concluded, "he hollers. If an alien is involved, he hollers to us."

Warren F. Holmes:

The Chair next introduced Warren J. Holmes of the Allis Chalmers Mfg. Co. in Milwaukee. Holmes first told a story of his experience in the Philippines to illustrate how strongly the idea is held in some parts of the world that labor is something reserved for the lower classes. Usually the foreign students we receive from overseas, he went on, are from upper-class families. "By giving these students experience in our shops and factories where the good work of our land is performed, we can contribute to the breaking down of the class consciousness which contributes to social unrest."

"The training of foreign students," said Holmes, "is a long-time and regular practice at Allis Chalmers. It is an activity in which the company's management takes particular interest and pride, but there are limitations as to what the company can do."

Addressing himself first to the positive side, Holmes pointed out that each foreign student who returns to his native land is a potential goodwill ambassador, not only for the industry by which he was trained but for America as a whole. There are now, he said, 7000 Venezuelan students in the U. S. "Properly handled these students and those that follow them should, upon returning to Venezuela, become a vast reservoir of good will between this important neighbor to the south and the United States." The benefits to be derived from these programs Holmes described as of two kinds: first, the indirect benefits which accrue to the nation as a whole as a result of improved economic conditions abroad; second, the

direct benefits which accrue to the company as the men they have trained return home and acquire positions of influence.

Turning then to the limitations as to what industry could do along these lines, Holmes stressed the high cost of offering such training. The cost to his company of giving two years of training to a foreign student was estimated at $15,000. Another limiting factor noted was the resurgence of foreign competition for the world market. "It would not seem wise to me," said Holmes, "for every industrial manufacturer to train British or German or Swiss or Japanese student engineers outside of those they use for their own operation."

The result, according to Holmes, is that only a relatively few of the many application received by industry from foreign students can be accepted. "American industry," he concluded, "is alive with the value of providing work experience for foreign students. But there are those inevitable considerations to sound business—costs, facilities, and competition—which limit industry's ability or willingness to participate in such a program."

Mr. Bollman:

The Chairman next introduced Mr. Bollman, the first of two speakers representing the Foreign Operations Administration, who asked permission to refer to his agency as FOA. (Mr. Bollman quipped that a few hours at the ASEE Convention had made him lose any feeling of self-consciousness over Washington alphabet soup.)

Bollman told the group that Mr. Gulick and he were present as representatives of the Industrial Technical Assistance Division (ITAD) of FOA. The ITAD consists of three branches: 1) The Technical Aids Division which supplies literature and such materials to people who have been in this country on the program; 2) The Technical Assistance Overseas Branch which takes care of requests for technical advice and help from other countries and has personnel going abroad to work; and 3) Technical Studies, U. S. Branch, of which both Bollman and Gulick are representatives. This division consists of four sections: 1) The Professional Engineering and Scientific Studies; 2) Development and Management Studies (Mr. Bollman's section); 3) The Work Studies Training Program (Mr. Gulick's section); and 4) The Processes and Technical Studies.

There are, said Mr. Bollman, 1951 participants under the Technical Studies, U. S. Branch, of which 772 are now in the U. S. Though this is no longer a new program, dating back to 1949–50, Mr. Bollman described the cooperation of industry as highly gratifying.

After a few remarks about the general operations of this program, Bollman turned to the question, "How can you (educators) use FOA to supplement the training of your foreign students?" The answer is that if it develops that a foreign student at a school in this country on a purely academic course needs practical experience, his adviser in the school can prepare an application to the student's sponsor in the home country for a continued training course in the U. S. under FOA. "That application is reviewed, and if it can qualify as a contributing factor to the current productivity program in that country, it will be processed and a formal application made to FOA in Washington for such training. In Washington it goes into the hopper and is handled in the same way as the 1951 projects mentioned earlier."

Bollman then went on to describe another program which he felt might appeal to educators. Despite cooperation from industry, he pointed out, there is considerable difficulty in placing many of the men who have graduated from schools abroad but wish to come here for practical experience. The FOA, he said, has developed with considerable success a plan for putting these people into our vocational high schools for part of their work. The advantage of this over university training, Bollman pointed out,

lies both in the people who attend and the equipment available. In a vocational high school, he concluded, they are placed in the company of "young Americans who are learning a trade or a skill and there they have an opportunity to work with their hands, get their hands dirty, and associate elbow to elbow with an American worker. Now it's not easy to sell some of these foreign nationals on that idea. But we are doing it and succeeding, and in this way these men are getting practical work experience, increasing their knowledge of the democratic ideas that prevail in this country, and learning that there is something in the dignity of labor."

Mr. Gulick:

Mr. Gulick, also of the FOA, described for the group the manner in which the Work-Study Training Program operates. This he described as a program for the "bench-level workers" who "in the future will be the leaders of the great masses . . . in those countries which are now friendly to us and which we hope will remain friendly."

The men trained, said Mr. Gulick, are between 22 and 33 years old, have completed apprenticeship and two years as journeymen, and come largely from the metal trades. Their countries are informed through our government of the Work-Studies Training Program. Biographical data on the applicants for training are sent to this country.

In this country preparations are made to accommodate a group of from one to two or three hundred. The agency goes into five or six cities which have at least fair employment ratings. There, continued Mr. Gulick, we talk to manufacturers, to the Chamber of Commerce executive, and to the leaders of the active unions. We talk also to other interested people such as the YMCA secretary, leading pastors, and acknowledged community leaders. We then ask a school recommended by both labor and industry to make a job survey. From this we learn what industry in the area expects the labor market to be in the near future for each of the crafts. We total the number for each craft for the cities in which we are working, divide the total by three, and assume that in three months we can place that number. These men are then ordered over from Europe. An attempt is made to draw them proportionally from the participating countries, but the ratio is also affected by the availability of men who wish to come.

After the men arrive in this country, they are cleared for security and taken to the area in which the jobs exist. Each man is taken by the FOA's supervisor in that city to the factory. Here he is interviewed. If he qualifies, he is given a job at the same pay as an American worker.

For a year he is an American worker and shares their experiences. He joins the Union and pays dues. He has the vacations and long weekends. Sometimes three or four of them will buy a car and tour to California and back during their vacation. A few have taken plane trips to Hawaii at their own expense.

But, Gulick went on, the men are not without supervision. In Chicago, where there were 65 men in one project, one full time supervisor was paid from FOA funds. He was assisted by an associate-supervisor from the CIO, who proved very useful in finding jobs. A full time secretary and an office were also maintained for the project.

In addition to gaining work experience, the men also studied English and American civilization. They studied management problems sufficiently to become conversant with industrial problems from the management standpoint. They also studied union organization, labor problems, and labor management. They learned, moreover, that our productivity, which exceeds their own by 30% to 100%, does so not merely because of machines, many of which they have, but because of

better factory placement, methods, and the like.

Thus in 12 months, Gulick went on, a man really gets a picture of America and of the laboring man's lot here, and he is better able to resist the blandishments of those who try to lure him with second-hand accounts of the perfection available in Soviet Russia.

The 12-months program Gulick described as neither too short nor too long. If it were longer, the men would become settled, and want to stay here. As it is, he reported, a few marry here and then try to come back. Many marry girls here who have immigrated from the man's own country and take them back home with them. But, concluded Gulick, even those who do return don't come back before they have had a few months in which to tell their story effectively.

Mr. Roland:

The Chairman next introduced Mr. J. W. Roland, of the Department of State. Roland explained that at this meeting he represented the International Educational Exchange Service (I.E.S), a branch of the Department of State which has in the last "couple of years become increasingly concerned with giving practical experience to foreign visitors to this country." This concern was said to stem from a growing conviction that "more would be accomplished if the experiences of foreign visitors are not confined to the theoretical and academic on the one hand or to programs of generalized observation and consultation on the other." As a result of this thinking a separate division of I.E.S. has been established. This new group, the Specialists Division, is concerned, insofar as it deals with foreigners, with giving practical training experience to these people.

Under this program, Roland explained, no attempt is made to place anyone in industry directly. The program is operated almost entirely through cooperating agencies, both contractual and voluntary. The student program of the Department of State is administered by the Institute of International Education under contract. But State is responsible for the planning of the program, the general supervision, and for selecting the people to come. These fall into four main groups.

Before discussing these four groups, Roland digressed to explain that the objective of this program is "to increase international understanding." Since we are trying to build favorable attitudes toward the United States, Roland continued, we look for people who are going into government and political life and will be leaders in that field. We look also for people who are active in all forms of community activity, for people going into journalism and writing generally, and for leaders of youth organizations. Roland explained that while no group is ruled out, the aim is to find leaders in as many areas as possible.

In differentiating the State Department program from the FOA program, Roland pointed out that FOA, where the two operate in the same country, deals largely with the economic and technical people, leaving the others to the State Department. Where there is no FOA program, the State Department may tackle any field. The difference between the two programs is one of primary and secondary objectives. FOA has as its primary objective economic and technical development and as its secondary objective the development of a "wider appreciation and understanding of American institutions, motives and policies." With the State Department these two objectives are reversed.

Roland then described in some detail the four groups of people for which the State Department is concerned to find practical experience and what it does for them. Briefly summarized these are:

1) Students coming in under United States grants. There were 997 of these last year out of a total of about 30,000 foreign students in the United States. In addition, State gave Fulbright Travel

Grants to about 1000 more who had found their own schools and scholarships. The State Department encourages all these students to get practical experience in their field, but does not assist them to do it.

2) People who are brought here on specialists grants of the Department of State, primarily for a program of practical training and experience in their own field. This group is small, about 200, and contains relatively few technical and industrial people. Those on this program are financed by the State Department except for newspaper men who are paid by the papers on which they work.

3) U. N. fellows and scholars. These are serviced by the State Department to the extent that in-service training is to be arranged in or through United States government agencies. About 150 applications for this kind of service are received annually. The people are maintained by their U. N. grants.

4) People sponsored by their own governments. The people in this group and in group three are trained largely in government agencies from which they may be reassigned to private industry for all or part of their stay. These assignments are in an extremely wide range of occupations.

Roland outlined, in conclusion, the following obstacles encountered in placing people:

1) limitations of time and staff;
2) danger of revealing trade secrets;
3) danger of foreign competition, generally;
4) reluctance to accept people from nationalized or socialized industries;
5) reluctance of plants doing classified work to handle people not cleared for classified jobs; and
6) the unemployment factor.

Roland's talk completed the initial round of speeches. Chairman Dawson, after introducing Professor R. P. Sinca from Dinbad, India, to the group, commented on the work of the panel. He expressed the view that though the members of the panel had interestingly outlined their own very worthwhile programs and the problems encountered in them, little had been said that applied directly to the question of how colleges and universities can do more to secure practical work experience for the foreign students that they are graduating. This, the Chairman insisted, is of primary importance. The mere interchange of people between countries is not enough, said Dawson, pointing to France and Germany as a classic example. "The ideas behind our program are what are important. We have got to make friends with these people and see to it that they do not go home frustrated if we are going to accomplish anything."

The Chair then recognized Dean Hamilton who stated that in view of the fact that 4000 foreign engineers graduated from American colleges last June, the figure of 156 foreign students trained in 58 large industries, cited by Maser, was not very impressive.

Maser responded that he had been somewhat misquoted. First, they were not all big firms; and second, they were not all 58 industrial firms. His survey, he went on, was designed to get a sampling of what business in general is doing for foreign students. He added that he had gained the impression from the survey that industry is very much interested in the general program and that many firms which had once trained foreign students but are not doing so now would be glad to cooperate again if asked.

Mr. Gulick then took the floor to suggest that the universities might profitably copy one aspect of their program. The FOA has, he said, what is called a Labor-Management-School Committee made up of representatives of schools, management, the C.I.O., and the A.F. of L. They represent the community to F.O.A. and are helpful in getting men placed in industry. Universities, Gulick urged, should try to set up similar relationships.

Dean Everitt of the University of Illinois then asked if there exists any or-

ganization through which information regarding the possibility of placing foreign students can be obtained. He pointed out that there is at present a great deal of "criss-crossing and wasting of effort" and asked about the possibility of some organization such as FOA operating as a center to find out just how many jobs are available for foreign students.

Everitt then theorized that the 4000 foreign students graduating in engineering could probably be given training in American industry without undue strain if all possibilities were systematically developed through some central organization. Recognizing that this would be expensive, Everitt urged, however, that it would cost far less than other types of foreign aid. Even if a survey were to show that only 1 in 10 or 1 in 5 foreign students could be placed, Everitt added, this would be useful as it would allow the schools to plan the foreign student's program realistically.

George Lobingier of Westinghouse was recognized next. He offered the opinion that the programs for training foreign students have never been effectively sold to management at the policy-making level. He also endorsed Everitt's suggestion that a clearing-agency be created and said that such an agency could do much to help sell top management.

Mr. Sherman Royal of Technical College, Scotland, told the group that they too are training foreign students. He expressed the view that these men could be more easily placed if they were required to have practical experience in their own countries before they were accepted.

Chairman Dawson responded that it was his practice to examine all aspects of an applicant's background, including his work experience. The Chair then recognized John Gammel of Allis Chalmers Co. who raised the question as to whether or not the ordinary undergraduate engineering program was suited for all of the people who come here and suggested that some work in a technical institute might be included.

George Mullin of Technical Recruiting, General Electric Co., said that people in his work must constantly take time to explain to foreign students that they cannot be hired on jobs involving government contracts. He proposed that much time could be saved for everyone if a bulletin were printed which set forth clearly the work areas open to foreign students and those open only to U. S. citizens.

In response to a question from the Chair as to whether all of GE's plants were classified, Mullin explained that though some of their plants are not classified, it is necessary in the building of a professional staff to hire men who can be used flexibly as their abilities and the company's needs warrant.

Cushman then offered the information that many firms have applied for permission to import engineers from abroad for use in unclassified work. "I don't know the answer," he said, "but somewhere here there must be an answer, as they are importing these people who cannot become citizens for five years and putting them to work immediately in plants where classified contracts are being offered."

Mr. Gulick explained that the responsibility for admitting people to plants working on defense contracts rests with the representative of the Department of Defense at the plant.

Dean Vivian of the University of Southern California commented that he felt that it was highly important to impress upon foreign students that practical experience is a privilege and not a right.

In response to a question from the floor as to how a foreign student who is in this country as a private citizen on a student visa can enlist the aid of FOA in securing practical experience, Mr. Bollman advised that the student write directly to the FOA mission in his own country. This should be done early as it takes

about twelve months to get the application through.

Mr. Cushman was then asked whether a man on a student visa could be paid a wage or salary. He replied that such a person could be gainfully employed.

Professor Black of Iowa State College then said that he had been plagued with the problem of getting experience for foreign graduate students. Many of these, he explained, badly need practical training before they can do graduate work profitably. Black commented also that he felt the government agencies should do more to clarify their own objectives and the regulations affecting practical experience for foreign students.

Cushman replied that the government agencies do try to coordinate their efforts. That they sometimes fail to do so perfectly, he pointed out, should not surprise people from large universities where the same kind of problem exists. The establishing of an information agency that could answer everyone's questions about all aspects of the government's complex and voluminous activities would be quite expensive, Cushman added.

Hamilton then directed a question to Cushman regarding the possibility of getting a year of practical experience for a foreign student going to school here on a student visa before that student has completed his college course.

Cushman replied that under the law practical training in advance of the academic program cannot be approved. A student may, however, apply for a change of status to exchange visitor. However, he cannot change his status again without returning to his own country.

Mr. Bollman suggested that it would probably be better if more students came as exchange visitors, for they then could take any combination of academic and practical training that their sponsors approved and their programs called for. Bollman added that his department is conducting a survey of the possibilities for finding practical experience opportunities. This survey should clarify the picture somewhat.

The point was then made (speaker not identified) that the urgency of action in this area is dramatized by statistics which show that while we trained 23 people from Indonesia last year, Russia trained 9000.

Another unidentified speaker then emphasized the great importance of sending those people who do receive training here back to their home countries prepared to do the work that needs to be done. He suggested that perhaps the countries from which the students come would be willing to subsidize training in specific areas that are of special importance to them.

Bollman then reminded the educators that FOA does provide a definite procedure through which the schools can obtain practical experience for their students and again urged that use be made of the facilities of the vocational high schools for this purpose.

In conclusion, Chairman Dawson expressed the belief that the International Relations Committee should work out some concrete plans and arrange for a conference in Washington.

Conclusion

Though the Conference did not produce any simple answer to the question of how to provide more opportunities for work experience for foreign students graduating from American engineering colleges, two very important points of agreement are apparent in the foregoing proceedings:

1) The representatives of education, industry, and government agree that enlightened self interest requires us to continue and expand the program of sharing educational opportunities with our friends abroad.

2) Practical work experience in this country is, in many instances, an essential supplement to theoretical training in colleges and universities.

The proceedings reveal also that there are many factors which now seriously

limit the program for giving practical work experience to our friends from abroad. Paramount among these are security needs, fear of competition, prejudice, apathy, limited facilities, complex and sometimes conflicting regulations, and lack of information. The need is apparent for cooperation at the top level among the schools, industry, and government to determine: 1) what work opportunities are available to foreigners; 2) how the number of such opportunities can be increased; 3) exactly what can and cannot be done under existing laws; 4) what changes are needed in the laws; and 5) how information of all kinds can be made readily available to all interested persons and groups.

Several proposals designed to promote more effective cooperation among the interested groups were made during the discussion. The International Relations Committee of the ASEE intends to follow through on these.

American Society for Engineering Education

Chemical Engineering Division

Fourth Summer School for Chemical Engineering Teachers

The Summer School will be held June 27–July 2, 1955 at The Pennsylvania State University, University Park (State College), Pennsylvania, following the annual meeting of the parent society. Three earlier Summer Schools for Chemical Engineering Teachers were convened at the University of Michigan (1931), The Pennsylvania State University (1939) and the University of Wisconsin (1948). All were very successful. As will be the case for the forthcoming sessions, emphasis was placed on practical help to the teacher by discussion of instructional methods and the presentation of illustrative problems.

Program. A varied program has been arranged under the general direction of Dr. Kenneth A. Kobe of the University of Texas. Technical presentations on reaction rates, process rates, process control, fluid mechanics, solid state physics, design and economics, and operational research are included. An entire day is devoted to mathematics in chemical engineering. Topics of great interest to teachers and administrators are: Accrediting of undergraduate and graduate curricula; a survey of undergraduate curricula; nuclear curricula; a symposium on unit operations *versus* engineering science; round table discussions on the teaching of the first course in chemical engineering, thermodynamics, unit operations, and on design and economics. A series of four lectures on educational methods and a presentation on student counseling will be given by staff members of the host institution.

Meeting Place. It is planned to hold the sessions in the air-conditioned Assembly Hall of the new Hetzel Union Building. Round table discussions are scheduled for various rooms in Osmond Laboratory across the street from the Hetzel Union Building.

A Professional General Curriculum in Power*

By JOHN A. M. LYON

Chairman, Department of Electrical Engineering, Northwestern University

Any subdivision of Electrical Engineering, particularly at the undergraduate level, seems arbitrary; training in a so-called option is not always purposeful. At the graduate level a much greater depth in specialized training seems justified. Although even here it is often difficult to classify a man by the frequently used categories "power" or "communications." Consider a man who has received his Ph.D. with original research in some part of basic Electrical Engineering, such as semi-conductor development. Each of us can see immediately the utilization of advances of this subject in either power or communications equipment. Let us recognize that labels are often misleading. Power industry personnel representatives very often say that they are not interested in the particular specialization within Electrical Engineering in which a student has studied. In this way I am led to conclude that we mean by power equipment manufacturing, or by power generation, transmission, and distribution, something very broad which requires above everything else good basic training. Actually the quality of the instruction and the competence of the faculty are more important than a list of the courses taken by the student.

We may very well wonder at this time what we mean by the term "power." I do not consider "power" to be synonymous with "d-c" or "60 cps" nor do I believe that "electronics" is the exclusive of the communications people. I use the word "power" as an adjective or classification to describe the production, transmission, utilization, and control of electrical energy. The power may be produced electronically, or electromagnetically, omitting other possibilities for brevity. With this meaning in mind, I am talking of a curriculum of interest to utilities, utility equipment manufacturers, control and instrument manufacturers and users, users and makers of high frequency process equipment, and the users and makers of a wide variety of digital and analogue computers.

Certainly in electrical manufacturing as well as in the production of electrical energy we must be cognizant of the electron tube, semi-conductor devices, and the saturable reactor as control elements. Renewed interest in dielectric and magnetic materials for a wide variety of purposes will bring advances in many branches of electrical manufacturing. With respect to the electric power industry I believe we all readily come to the conclusion that electric and electronic control, and instrumentation constitute a tremendous part of the activity. We in the power field must realize that electronics is as much a part of the field of endeavor as are network theory, and electricity and magnetism. I think that it is very regretable that electronics has been considered by some to mean "non-power," "communications," and the like. Somehow I think industry has been less to blame in making this incorrect distinction than the colleges and universities. At least in industry there was some excuse. A man who had had no electronic training hid under the name of "power." Communications people who first used

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so-called electronic devices were eager to seize upon the word "electronics" as something that belonged exclusively to them. I am afraid that colleges and universities have been guilty of agreeing to this misleading concept.

Many of use in college teaching together with our contemporaries in industry recognize the great need for studies involving more than one field of engineering such as electrical, mechanical, civil, etc. Industry has been helpful in the problem of determining the patterns of engineering education. I wish to point out that education has contributed, and must in the future contribute to the shaping and moulding of industry. Things that are being taught in the university classrooms and discovered in the university laboratories may very well be a part of the future of any industry.

In planning a power curriculum we should look to the future of the whole power industry in much the same manner as the utility system planning engineer. We should teach so that the student is prepared to meet problems in industry including the newer and most advanced problems. However, if we attempt to teach the student to handle the details of the individual technical problems, we would then be surely short-changing the student on fundamentals. Any curriculum in electrical engineering should be of sufficient depth so that the student upon graduation will have something technical to offer which is not available generally from graduates a few years before him.

I think that we should not strive to place students in classifications any more than necessary and justifiable by precedent. Just as industry makes use of individuals with different abilities and interest so should colleges and universities recognize students as individuals with very real differences. In so far as possible I believe colleges and universities should strive to develop the student along the lines of expressed interest. In this way I think the student is most likely to approach his full potentialities in life.

Keep It Basic

I believe the main requirement of any electrical engineering curriculum is to keep it basic; a large amount of specialization at the undergraduate level is unjustified; and a special designation in the degree offered should not include reference to this comparatively small amount of specialization within the general field of Electrical Engineering. I believe experience has shown the error in detaching Radio Engineering and offering a separate degree in that specialty aside from the degree in Electrical Engineering.

There seem to me to be two general methods of approaching this curriculum problem. One is to alter existing courses to include basic concepts of the power field. The other is to include in the curriculum specific courses in the power field. This latter approach would require the deletion of existing courses.

It is my contention that the future of an undergraduate electrical engineer is largely undetermined when he is an undergraduate. I personally know that some of the finest system planning and relay engineers in the electric utility field were enthusiastic about radio communications in college. Also I know of some of my former students, mechanical engineering students, by the way, whose main contact with Electrical Engineering in the university was in the service courses offered to them—these same men in the professional world are recognized now as able electrical engineers.

The main objectives in a professional general curriculum in Power should be:

(a) To develop the intellect of the student
(b) To supply him with basic concepts
(c) To stimulate and inspire the student for possible creative work
(d) To equip the student so that he is prepared to enter his chosen branch of professional engineering with a reasonable knowledge of the latest advances in this branch

(e) To render a service to industry and the engineering profession by supplying adequate trained individuals who are not merely capable of being assimilated by the profession and industry, but who may reasonably be expected to supply the profession and industry with new impetus.

These objectives can be realized with various power curricula. A curriculum has the best chance of successfully fulfilling its objectives if it is tailored to the abilities of the faculty.

My experience with employers indicates that they place a high value on good training in mathematics, physics, chemistry, the humanities, economics and business administration, and basic courses in other engineering departments. It seems doubtful if carving out a more extensive power curriculum at the expense of the above fields can be justified. It is desirable that the student in Electrical Engineering be allowed to take a few general electives from the above fields.

You will notice that electronics is involved in power, as is analysis of circuits, nuclear instrumentation, motor control, symmetrical components, analysis of power system stability, and other appropriate subjects. I still hesitate to say that every undergraduate student who expects to be in the power field should have courses entitled Symmetrical Components, Power System Stability, Power System Relaying, LaPlace Transforms, or Tensor Analysis. Rather undergraduates should have a limited knowledge of some of these plus a general knowledge of the usefulness of the other topics. Further, it seems to me that every power student should have facility with system analysis involving circuits utilizing both electronic tubes and machine elements, including control elements. The analysis of circuits should be general enough so that the students see the usefulness of similar methods for thermal, fluid and other flow problems.

I am not going to list courses to be included in a general professional power curriculum. Rather I would say that in some of the required courses the fundamentals of network theorems, superposition, symmetrical components and transform analysis should occur. More complete treatments can be reserved for elective and graduate courses. With the tremendous requirement for a basic knowledge, I doubt if most undergraduates can take more than two or three elective courses in the technical field of electrical engineering. Even then I would not insist that these electives all be in what are generally called power electives such as "Power System Stability," Symmetrical Components," "Relaying and Control," "Industrial Electronics," etc. I can see the desirability for a power engineer to take courses in almost any phase of electronics, advanced circuit theory, analog computers, digital computers, feedback systems, microwaves, etc.

Fundamental Concepts of Nuclear Processes

In line with the idea for training for the future, it seems to me that every electrical engineer should be trained in the fundamental concepts of nuclear processes. For a power curriculum, additional elective courses in nuclear reactors, and nuclear instrumentation seem desirable. The nuclear power plant projects at present being anticipated raise the question of whether or not there should be a separate curriculum in nuclear engineering. My belief is that nuclear engineering is an excellent example of the need for cooperation among the existing branches of engineering and, in universities, among the existing departments of engineering. There is a very important phase of nuclear engineering to which electrical engineers can contribute, and that is in nuclear instrumentation and control. The important problems of thermodynamics and metallurgy can best be solved by engineers primarily concerned with such topics. In

short, I believe our basic training of electrical engineers should deal with nucleonics much as our basic training deals with thermodynamics, heat engines, or theory of structures. In electrical engineering, training for nucleonics should be concentrated at the elective and graduate levels on control, instrumentation, and particle accelerators. In this way the needs of the manufacturers and of the utilities for engineers trained in nucleonics may best be fulfilled.

The power industry has to offer challenging opportunities to young men before this industry can compete favorably with communications and radio in the employment of recent graduates. Power engineers responsible for developing the engineering personnel of their organizations should not emphasize (1) importance of knowledge of equipment (2) servitude for the young engineer in subprofessional levels for the first few years, thereby perhaps forever limiting the vision of the young man. The power industry for its own further development should try to make use of the special abilities which the recent graduates possess and which the experienced engineers never had the opportunity to obtain.

In the universities we don't want to teach men just to do the routine jobs in engineering. Unfortunately, many young graduates now entering the power field find their ambitions thwarted by the apparently common practice of reserving the most intriguing problems for the older and more experienced engineers. Actually, I believe that in the power field too much weight has often been placed on experience. There is a real danger in this. We then find engineers brought up in the atmosphere of doing the same old thing in the same old way. Sometimes I thing that we should always have two types of designers available. One type to keep up with the latest in the industry, the other to be entirely uninhibited and not be concerned with what the rest of industry does. If we had more of the latter, we would have less stagnation in certain fields.

Conclusion

In conclusion, I believe in stressing the objectives of a power curriculum rather than a listing of courses. I believe in a curriculum utilizing the strength of the faculty. I warn against boxing in the subject of power so that a student gets a worm's eye picture of Electrical Engineering.

College Notes

Four new degree programs for graduate students have been approved by the board of trustees of **Stevens Institute of Technology.** Of the four new programs, to be offered starting next fall, three will lead to the degree of Doctor of Philosophy. These will be awarded for study in the Departments of Chemistry, Mathematics and Physics which already grant the master's degree. The new doctoral programs will be in addition to that in applied mechanics now offered by the Department of Mechanical Engineering, for which the degree of Doctor of Science is awarded. The fourth of the new programs is one leading to the degree of Master of Science in Civil Engineering.

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The South Dakota Legislature in its 1955 session appropriated $850,000 for a new engineering building at **South Dakota State College.** The building is being planned at the present time. Completion of building may be in 1957.

Educational Requirements for Design and Development Engineers*

By WILLIAM E. BRADLEY

Director of Research-Technical, Philco Corporation, Philadelphia, Pa.

A report on the subject of educational requirements for design and development engineers must begin with the comment that we are more dissatisfied with the *quantity* of the applicants than with their quality. There has never been a time when so many challenging design and development positions were available in the communication field.

Of course the manpower shortage in these fields is only partly due to a reduction in the number of engineering graduates. In large measure it has been caused by industry expansion in highly technical fields so that there is an increasingly great demand for men capable of filling design and development positions.

I will try to present a summary of those educational requirements and related matters which seem to me to be most important. I am not in a position to judge which of these are most readily applicable to the planning of actual engineering courses by the schools. The most important subjects in this connection will be presented in approximate order of priority, from our own point of view.

Personnel Type for Design and Development Positions

It is our opinion that adequate education is a necessary but not sufficient condition for a successful engineer. Both design and development positions require, in addition, certain inherent talents and abilities. Engineering schools perform an extremely important function, in addition to their educational activity, in *selecting* appropriate personnel types.

However, a difficulty appears at this point. There has as yet been developed no system of grading students which gives much indication of the *relative* talents and abilities of the student in each subject as compared with the average of his colleagues. This comparison is very important because to some extent college grades can be used as aptitude test data. This is a much more powerful method of personnel selection than the use of *average* grades.

I have often been in some doubt upon examining a transcript of the grades of an applicant as to the value of the present grading system to a prospective employer. For example, I might observe that the applicant had a mark of C in a course in differential equations. The question that immediately comes to mind is whether the rest of the class averaged B or D since only thus can I conclude whether this man showed more than average ability or below average ability in this important course.

The grade received by a student in one isolated course is, indeed, almost meaningless without additional data. If this grade had been attended by a statement of the average grade received by the entire group in this course and if, also, there were a notation of the number of semester hours of study to which the student was committed during the semester when the course was taken, a great

* Presented at the Annual Meeting of ASEE, University of Illinois, June, 1954.

deal of valuable information could be derived. Strong individual differences between students can be distinguished from the *pattern* formed by their departures from class average in each course. Our most successful design and development men show very clear-cut patterns or correlations in this respect and we have come to the conclusion that very valuable data concerning the personnel types could be obtained by a relatively small amount of additional information furnished with the transcript of grades.

Of course we have no *rigid* rules relating mathematical correlations, derived from academic grades, to suitability for employment, but we do allow these correlations to prejudice us. It is probable that the research for correlation between the pattern of grades and industrial success in particular fields is an appropriate job for industrial personnel departments since position requirements vary from company to company. On the other hand, the development of a grading system that would make the study of such correlations possible is clearly appropriate to the educational institutions and we very much wish that this could be done.

Thorough Grounding in Basic Theory

An engineering course is necessarily a mixture of two components. One of these is training in *basic* theoretical *principles* and their broad application. The other is training in the *engineering practice* of our generation. In our experience, these two types of training are not of equal value. Basic theory does not change, whereas engineering practice does. It is impractical for engineering schools to keep entirely up-to-date with present-day practice whereas, due to their more permanent nature, engineering schools can teach with assurance fundamental physical laws.

We have many times wished that our young engineers had more training in theoretical mechanics, Fourier integrals, vector analysis, electromagnetic theory, optics, and elementary atomic physics, whereas we have seldom had reason to complain of a man's lack of knowledge of practical equipment *except* in cases where the personnel type was not appropriate.

I am sure that this point has often been made before and that our point of view here is not at all unusual. However, no account of our opinion regarding educational requirements for design and development engineering could be correct without the statement that training in fundamental physical theory is in short supply.

Application of Theory to Practical Situations

Strong differences appear among men of nearly equal education in their ability to apply theoretical knowledge to practical problems. Since a number of men have shown marked improvement in this ability during their period of employment with us, we believe that it is not an inborn talent but that it can be learned from experience. We are not certain what could be done in an educational institution to improve this ability but, surprisingly, there does not seem to be a very close correlation between an engineer's ability to solve a textbook problem, which is clearly stated in language to which he is accustomed, and his ability to deal with easier problems which arise from day to day in the course of laboratory work. Perhaps the truth here is that the student needs practice in the process of *problem definition*. To *define* a problem relating to a physical system is a kind of abstraction process. Anything that can be done to improve the engineer's ability to *relate* actual physical phenomena to the laws and principles which he has learned in school would be of immense value.

The most important factor in learning how to apply theory is, of course, actual exercise in such application. A compromise is necessary between the extent of the framework of theory to which the student is exposed and the thoroughness

with which he learns each part of the framework. The distinction between a superficial knowledge of theory and a working knowledge of the same theory is like the distinction between a reading knowledge of a language as opposed to a speaking knowledge. A speaking knowledge can only be acquired by actual practice in speaking, and a working knowledge of theory can only be obtained by applying the theory to idealized cases. The cases should be preferably idealized because the intent of the process is to fix the theory in the mind of the student. The amendments necessary for practical applications should be learned on the job, not in school.

Laboratory work in the engineering school may or may not assist in this type of training. During his college years the average student is studying so many subjects simultaneously and has so little time for relaxed thinking that he is very likely not to do justice to the challenging problems presented by even a very good laboratory course. In that respect, work in industry is very different from the type of effort required of a student in engineering school. It is the rule, not the exception in industry, for a man to spend many days or even weeks on a single subject or problem whereas in school the ability to switch off his interest in one subject and turn it on in another on short notice contributes greatly to his performance. This quality may not even be desirable in industry. The requirement that during his education a student focus his attention *in rapid succession* on many rather diverse subjects is one important cause of the well-known discrepancy between college grades and success in industry, at least for design, development, and research positions.

Training in the use of approximate methods of analysis is a closely related subject. Very rare is the design or development problem which does not involve approximate rather than exact application of mathematics. A skilled engineer not only has a repertory of standard approximation methods, such as linearization of nonlinear systems, expansion in series, approximation of integrals by sums or sums by integrals, and so forth, but he also knows how to guide these approximations by a still more vague sense of proportion derived from a clear visualization of the physical factors of the problems. Again, many engineering schools fully appreciate the importance of this subject but I would like to emphasize that its significance in practical work is very great.

Engineering Decisions

A little observation of the actual practice of engineering in industry shows that such positions require important activities for which the engineer receives very little guidance from his engineering training. It would be very helpful if a little more emphasis could be placed upon the nature of engineering decisions, upon the manner in which responsibility is allocated in engineering organizations, and on the conduct of the typical small meetings in which technical group decisions are made. These things are, at present, part of the folklore of the profession and for many years after graduation a student is likely to be reckless when he should be cautious or the opposite. He does not fully appreciate the extent and limitations of his responsibilities, and does not know how to conduct himself in a technical meeting where he may be called upon to present important evidence and to help decide important issues.

Perhaps engineering schools should make a study of some of these aspects of an engineer's work and determine whether or not these things could be taught in an orientation course for upper classmen. I have heard that some steps in this direction have been taken in a few schools.

Conclusion

It can be seen that the foregoing comments can be summarized under two headings.

First, from our point of view, we wish that we could use scholastic grades in some degree as indications of the *relative* aptitude of the student in various fields. Normalized grades could accomplish this and would greatly assist us in finding positions to fit the characteristics of the available men.

Second, we would like the engineering graduates to be prepared for the decisions which they must make in typical research and development activities. Such training should prominently feature as extensive as possible a framework of theory with plenty of practice in its application to *idealized* cases.

Some general training in the process of technical decision-making would also be appropriate, although this subject does not seem to fit existing scholastic categories and the content of such a course should be based upon observations of the actual practice of decision-making in development and design engineering organizations.

In the News

Establishment of the Office for the International Geophysical Year of the **National Science Foundation** has been announced. The new office will be headed by J. Wallace Joyce.

The International Geophysical Year is a world-wide program of special observations of various earth-science phenomena planned for 1957–1958. Under the auspices of the International Council of Scientific Unions, thirty-eight nations have already agreed to join, during that year, in a vast effort to collect synoptic data in such fields as geodesy, meteorology, the upper atmosphere and ionosphere, oceanography, earth magnetism, and latitude determinations. The purpose of the program is to develop more fundamental knowledge, which in turn can lead to direct benefits to all mankind.

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The 47th and *largest* Annual Meeting of the **Air Pollution Control Association** will be held in Detroit from May 22 through 26, 1955. Membership in the national association, which is interested in all phases of air pollution control, includes representatives from industry, trade associations, educational institutions, and local, state and national groups. Air pollution control experts from the United States and Canada will report on the latest findings in smoke abatement, air pollution measurements, odor control and new developments in abatement equipment.

Evaluation of Engineering Teaching Ability

By T. H. EVANS

Dean of Engineering, Colorado Agricultural and Mechanical College

The evidence of research is a publication of results and conclusions; that of useful professional activity in a national society is work on worthwhile and active committees, or as an elective officer who leads the society to useful achievements; that of educational background is advanced degrees; that of prestige is the seekers for advice from outside the college; that of scholarship is publications such as textbooks, supplementary notes, technical papers, or discussions of technical papers of others; that of background of professional experience or private consulting practice is the concrete creations of such work.

All these activities in which a faculty member might engage are measurable and can be evaluated for merit. But what is the evidence of good teaching? Can it be measured in a similar manner? If not, how can it be evaluated?

The problem of evaluating correctly the teaching ability of members of an engineering faculty has been discussed probably since the beginning of ASEE's predecessor, SPEE. Yet no one today seems to be able to give a universally acceptable answer to the question of how you do it. Perhaps we worry too much about something that has no definite solution; but since someone *is* always worrying about it, it appears that administrators will have to keep searching for a good solution. This is an effort to define the problem in order at least to help clarify the writer's own thinking on the subject.

Methods of evaluation today seem to run all the way from pure opinion based on a teacher's habits and personality, to elaborate numerical rating systems based on publications, degrees, society activities, talks, courses taught, and what have you. What is right and fair for *both* parties concerned? That is the problem for which most of us would like to have a good answer.

Since answers will vary with just what is wanted it will probably be well to try to limit the problem with definite specifications. As the writer sees it, the problem is to determine *how effective as a teacher of engineering subjects* is the man who is hired primarily (but not necessarily exclusively) as a teacher. The problem is affected also to some extent by the administrative level at which the evaluation is being done. One above that of the departments seems desirable since in many schools that is usually final, and it is also the first level at which overall coordination and uniformity must be exercised. To boil it all down then, the writer sees it as: how may a dean evaluate properly the teaching ability of an engineering teacher? While the dean is not always close enough to the teachers to observe them at work he still has the responsibility of coordinating the recommendations of a diverse group of department heads to be sure both the school and the individual are treated fairly. Even though all department heads are sincere and unbiased, their various methods of evaluation may cover the spectrum from one end to the other.

To arrive at an acceptable definition of what good teaching is may not be difficult, but there is extreme difficulty in deciding how to measure what a man is doing as a teacher. The latter is our problem. At

this stage at least we are trying to measure the man's *teaching ability* and not his overall worth to the institution.

We might start by reviewing two extremes which have been used in evaluating a teacher's ability. On the one hand we have a fairly objective method that measures a teacher in terms of advanced degrees, research, publications, activity in national societies, civic affairs and campus committees, prestige, etc., in addition to his classwork. This method has been criticized as evading the issue since most of the items used are not a direct measure of a man's teaching ability, and we know of people who do many of these things well but are still poor teachers. It also has many champions who point out that these things can measure the man's teaching ability since they are backgrounds he must have to teach engineering.

Then we can go to the other end of the spectrum and find a purely subjective system in effect, in which many human or personal traits are used as a guide. In this system the items mentioned in the preceding paragraph are looked on with abhorrence, sometimes to the extent where a department head may even discourage members of his staff from engaging in them. Factors which have been considered here are: enthusiasm, a sincere interest in the development of young people, knowledge of subject matter, attitude toward teaching, intellectual honesty, ability to inspire and stimulate others, ability for self-expression, tolerance, ability to cooperate, judgment and tact, professional attitude, originality and ingenuity, personality, etc.

This extreme has been criticized also for various reasons. For one, many of the factors listed are no more a direct measure of teaching ability than those in the other extreme. The ones that might be interpreted as directly measuring teaching ability (e.g., ability to inspire and stimulate others) usually cannot be measured in any reliable way. Since most of the items, even if directly related to teaching ability, are not capable of quantitative evaluation, the system boils down to subjective judgments. These are criticized as being liable to opinion, prejudice, emotion, friendship, or just plain charity. This method appears to have no more universal acceptability than the other at present.

The unusual and outstanding small group of distinguished teachers, some of whom we all know, are not our problem. They are usually easy to spot because everyone—students and colleagues—feel they have some spark that makes them outstanding; and then most of them do something besides just teach. Perhaps it is the latter that causes them to be outstanding. Our problem is with a great mass of engineering teachers who are not distinguished outside of their classrooms, but many of whom undoubtedly do an excellent teaching job. Also many of these better ones do not care to do anything but classroom teaching. How may an administrator evaluate properly their ability as engineering teachers?

Since the two evaluation extremes mentioned have both good and bad points, and neither has been universally acceptable, it seems that a compromise would be better to perhaps retain the advantages from both systems. This would be a compromise between purely objective and subjective methods, with a hope of being able to measure not only the quantity, but the merit of all items considered; tempered, of course, with human understanding and good judgment. It appears also that we must retain many items that may not measure directly a man's teaching ability but which, if indulged in properly, could improve it.

Instead of using a negative approach and shunning any characteristic because it does not directly measure teaching ability (having a Ph.D., or tolerance, judgment and tact, for instance), or because it could be overdone and detract from a man's teaching (too much research for example), it seems a positive approach would be much better. In other words,

if the characteristic *could* make a man a better teacher, then try to use it. It would be up to the evaluators to determine the merit of any item and to keep things under control so that poor teaching was not rewarded just because the man had an impressive record of other things. To never have any such items to evaluate for their merit is what bothers some administrators.

Now we come to the evaluation of a man's overall worth to his college. This has probably been confused a lot in the past with his evaluation as a teacher. If a man is a poor teacher he should not receive any rewards for his teaching, although he may have considerable other value to his institution. If two men seem to be about equal as teachers then perhaps one is worth more to his college than the other. This is a matter for administrative determination, but each level of evaluation must always keep clearly in mind also the objective of rewarding good teaching if it can be determined with certainty. Good teaching should also mean something special, something above average, something more than mere acceptability.

It is proposed that the good teacher is a creative man of many ideas, great originality, and enthusiasm for teaching, who will spend most of his time in professional development of appropriate kind. He should be creative whether it be in classroom teaching, writing, research or professional activities. As Julius A. Stratton, provost at M.I.T., so succinctly stated it: "Teaching and the quest of knowledge go hand in hand. A society of teachers with no interest other than that of conveying knowledge acquired by others will wither away." A school can be no better than its teachers; if they are "satisfied" men then there is a big question of its ability to progress and keep up with the times. To improve curricula and to attain prestige the engineering school must have a faculty of excellent teachers and scholars.

Too many people seem to be thinking about stereotyped drill through a subject when they speak of "good teaching." The teacher may spend a lot of time getting up his preparation from a textbook and in grading problems, but unless he does special things to get the subject across, such as novel training aids, unique laboratory equipment for demonstrating basic principles, original special problems of the integrated type, individual problems in design courses to arouse the creative desire of students, considerable supplementing of textbook material with special notes, or a gift of inspiring people, he still might not be too effective. A typical case is the loyal, conscientious worker, who without imagination, originality, or contribution of his own, religiously follows some standard text from year to year in his course.

Since the outward evidences between him who just drills his class and may be a poor teacher, and him who is really good but does nothing professionally outside of classes, are so elusive for positive identification of the real differences, we can have cases of stagnation, retrogression, or plain inability in individuals that might be hard to detect. The responsible administrators could have extreme difficulty in really knowing which was the better teacher unless there were other measurable characteristics to go by. The good teacher who is full of ideas, and trying to develop as a teacher, must keep up with his profession. To do this he must at least study the current technical literature. It seems a *minimum* outlet for his thoughts and ideas would be written discussions now and then on the papers of others. Just studying the work of others, and perhaps attending society meetings, but never writing or saying anything, gives the impression that the individual has no ideas or originality. If he has not, can he really be a good teacher? Many excellent teachers are probably going undetected by their department heads or deans because they are hiding their light under a basket.

A good department should perhaps

have balance between those who are devoted primarily to teaching and those who have broader interests. With a preponderance of either, its students may suffer lack of good teaching. A department may be dull, colorless, behind the times, and academically isolated if all its members engage in no worthwhile professional activities outside of their classroom work. It will achieve no distinction or prestige even though all its members are good teachers. Where a department head actually discourages broad professional growth because he feels it interferes with good teaching then there can be a big question if the teachers are as good as they might be. The other extreme can be bad too, but an administrator and a school would usually be better off to have to hold activities down a little than the reverse. To achieve real balance, a department must have some who engage in the different professional activities mentioned before, and then some perhaps who just want to teach.

The type of alert mind that seems essential to good engineering teaching usually would not be content to teach only within the classroom. It appears only natural that such a person would want to get his ideas out to his profession, to his fellow teachers, as well as his students. To do this he would want to speak now and then at meetings, write discussions of other's papers, write a paper himself on occasion, perhaps do some research or consulting. These outlets for the fertile mind are not "extracurricular" because most of them serve as a feed-back to keep the teacher more progressive, more alert, and professionally developing. While perhaps not directly a measure of his teaching ability they are the necessary background for teaching engineering.

After concentrating on this evaluation matter for several years now, then writing it down with revision after revision in attempts to clarify thinking further, this writer does not feel he has the answer by any means. Like all matters having to do with human behavior it is certainly not subject completely to mathematical interpretation.

It seems clear, however, that the good teacher must continue to develop his professional background, and show some evidence of scholarship beyond his last degree. If he chooses to confine all evidences of his ability to the classroom alone then he will still be a difficult case to judge. Since we need something besides pure opinion, perhaps such items as initiative, interest in students, ability to express himself, considered student opinions, knowledge of subject matter, originality, enthusiasm, ability to work with others, devotion to duty, outside reading, development of training aids, supplementary class notes, creativeness, type of problems required, character, use of spare time, etc., would be helpful in evaluating such cases. It would be up to the department head to present as much concrete evidence as possible on any items used. Some, of course, can't be judged objectively; others can. We still have human beings to deal with and must be just, fair, and unbiased. Administrators also have obligations to the students and the institution, however, and therefore need evidence to substantiate their own feelings of tolerance and charity toward their fellow men.

The cases of those who want to push their teaching, scholarship, or technical ability out beyond the classroom for the benefit of the public, or other engineers and teachers, give evaluators a lot more to go by. The man who does essentially the same things in the classroom as the teaching isolationist, but who is also more active professionally, gives an administrator much more to get his teeth into in making an evaluation. It appears this latter case should be based on all the evidence available, including the same as suggested in the paragraph above. The extra items here might be such things as publications, society activities, research, consulting, public service, current industrial experience, prestige, etc. Per-

haps the man's worth should be split into two parts—that in teaching, and that to the institution in other ways. If any of the new items introduced in this case can be shown to contribute to his teaching ability then they should be used there too. Most of these items are assessable both quantitatively and objectively for worthiness.

Taking the two cases for comparison now—both are judged on their teaching ability on the same basis for all available evidence that honestly applies. In addition the one is judged on his extra value to the institution. The individual's reward would be the sum of the two results in one case, and only one in the other. A really superior teacher (who does nothing else) could very well have a total value greater than the man who did lots of things but whose teaching was poorer. However, for two judged about the same in teaching ability the more active man professionally would reap the greater reward.

To make *any* system work it would be necessary that the dean assure himself that each department is presenting evidence on the same basis and in the same way. This in itself is extremely difficult, but if all administrators concerned honestly intend to be fair to the institution as a whole, then it must be done. If a system could be devised where points were assigned to each item it would be a great boon. However, the use of points for items is liable to become a trap because of its apparent simplicity and ease of use, since points themselves may be a matter of one man's opinion. A point system that is used only as a rough guide, the results of which are then tempered by the necessary subjective and human considerations, may be a satisfactory answer if the proper items are used.

The writer's own present conclusion after all previous cogitation is that a method of considering items that can fit into two categories—teaching, and extra—with point values used as a rough guide, and not forgetting that all this concerns human beings and not machine parts, appears the best answer until someone proposes something better. Whatever the system, all faculty should be aware of it in a general way so individuals would know definitely on what they were judged.

If such a scheme as proposed above was found worthy the details and method of application would be a matter for determination by each individual school, because of the variations in organization, faculty characteristics, and items considered important.

Comments on this subject are invited. —EDITOR.

What is Wrong with Surveying?

By MICHAEL V. SMIRNOFF

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One frequently hears discussions among engineering educators about a proper place of surveying courses in modern engineering curricula. Interest in this subject may be traced either to the overcrowded conditions of these curricula or to a questioning attitude as to the value of surveying courses in engineering education. Since engineering curricula vary considerably among engineering schools, it is necessary to point out that discussion in this paper pertains chiefly to the first semester surveying course. It is further assumed that this course in elementary surveying is required of all engineering students.

When the American Society of Civil Engineers was organized over one hundred years ago, the name Civil Engineer was used to imply a distinction from the Military Engineer. A civil engineer in those days could hardly be imagined in any other but outdoor surroundings—manipulating some tools and instruments that were supposed to determine certain lines on the ground delineating states, counties and townships, fixing property lines, locating railroads, etc. A civil engineer was then either a surveyor or a construction man, to whom the chain, the transit and the level were indispensable tools in his work. Long years of apprenticeship were required to acquire the magic skill necessary for the successful operation of these tools.

When engineering curricula in colleges began to take a definite shape, it was natural that surveying courses assumed a place of importance among other subjects to be taught in those schools. One can even wonder what an engineering student of those days could have been taught beside surveying. Concrete was unknown, metallurgy was primitive, electricity undiscovered, properties of materials, stress analysis and other prominent engineering interests of today existed in those days only through rules, applying to construction the knowledge acquired through intuition and earlier experience. Occasionally, ignorance or a mere accident produced something which was better than the expected result. The new procedures were then carefully noted and were regarded as the new standards of perfection. Everything was learned, more or less, as a trade. It took a long time for scientific experimental and theoretical approach to replace the old method of learning. However, the current methods of teaching surveying have not fully made the transition to modern methods. Surveying is continued to be taught as a trade course.

One immediate reaction to this situation may be that surveying is a sort of a trade, and as such should be taught in trade schools and be thrown out of engineering curricula. However, this position would be hard to defend. Engineers certainly would not want to call a surveyor every time they need to measure a distance, angle or elevation, as they would call a plumber to repair a bathroom fixture. Besides, if they had to do that, they would soon discover that wherever a measurement is concerned they themselves would have a lot to say about it since much in the engineering profession is done through measurements and depends on measurements.

The word surveying, according to Web-

ster, is "that branch of applied mathematics which teaches the art of determining the area of any portion of the earth's surface, the lengths and directions of the bounding lines, the contour of the surface, etc. . . ." Many people require just that to be done. Such business employs many surveyors who have never gone to a college and who have learned the trade in apprentice-like fashion. This proves only the fact that there is a place for surveying in subprofessional schools. A college graduate is not likely to go into that business unless his professional field gets awfully crowded. On the other hand a college graduate is likely to meet many situations in which he would be required to pass a sound judgment on the methods and instruments to be used in measurements.

The writer recalls witnessing construction of a through truss bridge having a 140 ft. span. The distances, center to center of pedestals bolted to the top of piers, were supposed to match the length of trusses which were assembled on the ground. The man doing the measurements for the contractor was not a college graduate but had a good training in field measurements. He made the measurements satisfactorily but he never was sure enough that his measurements were sufficiently correct. It never occurred to him that if the allowable error in measuring a span length were about one inch, the required precision ratio in measuring 140 feet would be about 1/1700, and that such precision could have been achieved by him with about one third of the accuracy that he would exercise under ordinary conditions. It is in the assignment of precision ratios and in the determination of the proper means for attaining them in actual measurements that the skill and trained judgment of the engineer is required.

The interchangeability of large parts of machinery and structures presents another example where good engineering judgment in measurements may be extremely important. The difficulties encountered in such cases mount rapidly with larger dimensions. Various optical instruments are now being designed and used in measurements where close tolerances are required.

General Principles of Measurements

A surveyor may do his ordinary land surveying work quite satisfactorily with an old transit and the like, but an engineer may be expected to know many other available methods of measurements as well as the degree of reliability that can be expected from each method and instrument. If his work deals with measurements, the engineer must be ready to answer questions about how close various parts or lines or angles must be measured and what may be wrong with a method, an instrument or a procedure. It may be expected that a good deal of information about the general principles of measurements should be acquired by engineering students in a course involving surveying.

The course in elementary surveying normally starts with explaining how to measure distances with a steel tape and how to apply corrections due to incorrect length of tape and variations in temperature, tension, sag and slope. A chapter in taping thus offers a unique demonstration as to how all systematic errors affect measurements. Derivation of formulas pertaining to corrections for these systematic errors involves the use of converging series, coefficient of thermal expansion of steel, unit stress, unit strain, unit weight and the moment of forces. However, a quick glance through surveying texts reveals that many texts in elementary surveying do not even show the derivations of all those formulas. Thus a student is obviously expected to "plug in" certain values in a formula and come out with the answer. In his next engineering course, however, he is likely to be admonished never to use a formula blindly.

The method of measuring distances

with a subtense bar * and an one-second theodolite eliminates the tape and corrections due to systematic errors, but it requires understanding of the theory of accidental probable errors. Although this particular method of measuring distances is not suitable for the first semester students, there are many ordinary rules and operations in plane surveying which are based on the theory of accidental probable errors. Since very little about these errors can be found in most texts on elementary surveying, it is customary to learn certain rules and operations without understanding the reasons underlying them. This method of learning brings inevitably that atmosphere of a "trade course" which was mentioned above.

After taping, the instruction usually passes to differential leveling with a dumpy level and a Philadelphia leveling rod. This method of determining difference in elevations follows a standard procedure which is taught and practiced throughout the country and meets the requirements for ordinary surveying work. There are at present time other levels some of which can do better and faster work. There is also on the market a self reading tape-rod which reduces the notekeeping to two columns, one for stations and one for elevations. The rod has its limitations but it is a wonder tool for certain types of work. A midwestern surveyor who used this rod for many years, mailed a questionnaire to some 50 colleges and universities asking for comments on the rod. According to his report, the answers can be approximately grouped into the following three categories:

1. Not familiar with it.	20 replies
2. Do not teach its use.	20 replies
3. Mention or teach its use.	10 replies

Three reasons may be expected to be advanced to show why college instructions in surveying must adhere to old standard methods and equipment. a) The old standard equipment can do surveying work of ordinary precision satisfactorily. b) Replacements are costly. c) Anyone who has learned how to operate the old instruments should not have any trouble with newer equipment.

These arguments tend to keep surveying instructions at a trade level and quite stationary at that. But there is no need to keep them at that level. First of all the students must be taught all the theory involved in measurements and applicable to other measurements as well as to surveying. Second, newer methods and equipment need only be used for demonstration and explanation of what can be achieved with them. Third, the acquisition of skills in operating surveying instruments should no longer be regarded as the primary reason for doing the first semester exercises, especially if they are given to all engineering students.

The dumpy level is usually followed in instruction by a transit; that good old American transit which is so familiar to engineers. It weighs about a "ton" and never fits into its own box. This instrument, which would have delighted Ferdinand Hassler, has only one thing wrong with it. Like the level, it does surveying work satisfactorily. One can see nowadays many transits of foreign manufacture which, due to cheaper production, find wide distribution. These are optical theodolites. A one-second optical theodolite is comparable in weight to a standard American transit. It can do first order surveying work and can be used with a subtense bar for measuring distances. This instrument should also find many uses in industry. These optical theodolites are fine instruments, worthy of any engineer. The writer has spent one delightful summer working with them.

The outline of the main topics in the rest of the elementary surveying course should include the stadia method, computation of areas by various methods and public land surveys. The derivation of formulas for the stadia method and the

* See writer's article on "The Use of Subtense Bar," *Surveying and Mapping*, Oct.–Dec., 1952.

areas give just as good application of algebra, geometry and trigonometry to practical problems as can be found in any lower division engineering courses. It may not be fully realized how much an entering freshman can learn in a course like elementary surveying. It may be made most helpful and useful, preparatory for a further sequence of courses in engineering.

Conclusions

In a summary the following conclusions can be made:

a. Surveying has remained for too long sedentary and on too low a plane. With newer and better equipment and a wider scope of application it could be revitalized and made more useful and interesting.
b. It is more important to teach future engineers what methods and equipment can be used to accomplish certain results than to teach what results can be accomplished with old standard equipment.
c. Since all engineers use measurements, a course in surveying could be made practically equally useful to all engineering students. It should include the fundamentals pertaining to any measurements and applicable in any field.
d. Surveying measurements are particularly suitable for demonstration of principles of measurements and should be used to accomplish that aim. The surveying part will then take care of itself automatically and in a more enlightened fashion.
e. If surveying is one of the first engineering courses on students' study program, it must include all disciplines pertaining to engineering. In fact it must demonstrate the engineering method and approach.

Although the discussion presented here had in view only the first semester surveying course, some changes may be deemed welcome in other surveying courses. In the opinion of the writer they should be revised with a view of giving priority to newer methods and better techniques. Among these, for instance, the emerging science of photogrammetry should find its proper place.

ANNUAL MEETING

June 20-24, 1955

Pennsylvania State University

UNIVERSITY PARK, PENNA.

(formerly State College)

Mechanics Conference*

The Objective of Instruction in Undergraduate Mechanics in Physics and Engineering

The conference found, after a careful analysis of the statements of the objectives of undergraduate instruction in both physics and engineering, that the objectives are not competitive in scope but actually complementary when the courses are properly planned and taught. It cannot be over-emphasized that the instruction by physicists will provide the engineering student with an understanding of physical phenomena basic to much of his later studies. On the other hand, the objective of instruction in mechanics by engineers is to achieve professional competence in the practical solution of problems encountered in engineering.

We conclude, therefore, that there is an essential difference in the approaches to mechanics by the physicist and the engineer. There is a place and, indeed, a need for both of these approaches to the teaching of mechanics. The different objectives should continually be recognized and used as guides in planning courses.

Objectives of Physics Instruction in Mechanics

The primary objective of physics instruction in an engineering or scientific curriculum is to provide the student with an understanding of the physical principles that describe nature, of how these principles have evolved, and of their scope and limitations. Such an undertaking must begin with the study of Newtonian mechanics. Great emphasis should be placed on the conservation principles. The generalization of these principles along with associated concepts has formed the basis for modern physics, including such special branches as atomic and nuclear physics and the physics of the solid state. With this approach, it is neither practical nor desirable in the physics course to devote attention to the development of facility in detailed application of physical laws to practical problems encountered in engineering practice. Stimulating problems should be selected with a view to illustrating physical principles, and it is essential that they be accompanied by a challenging laboratory experience. These courses, approached in this manner, should provide an adequate base for the student's continued scientific growth.

In order that the study of Newtonian mechanics be effective in setting the stage for a proper understanding of the concepts and methods of modern physics, it must be recognized that a significant difference exists between the older physics and much of modern physics. In modern physics a large amount of theory is often interposed between observations and the conclusions based on them. Nevertheless, the pedagogical approach in which macroscopic observations are used directly as a guide in building theory must first be employed, as it can in mechanics; the student must later be led to the present day methods of inferring conclusions regarding phenomena not directly observable. These methods are in fact used in kinetic theory, optics, and electricity, as well as in many topics of modern physics.

To achieve this goal, the role of con-

* Held at New York University, February, 1955.

servation laws in mechanics and electricity can hardly be over-emphasized. The study of mechanics should also include the dynamics of systems of particles, wave propagation, standing wave systems, etc. Valuable for later work in modern physics will be the study of resonant systems, such as the mechanical harmonic oscillator, accompanied by demonstrations or discussions of similar resonant systems in electricity, nuclear-magnetic resonance, and examples from acoustics and optics. It is in this spirit that instruction in mechanics makes a significant contribution toward the understanding of phenomena in atomic, nuclear and solid state physics.

Objectives of Instruction in Mechanics by the Engineer

The prime objective of instruction in engineering mechanics is to provide the student with a useful understanding of the methods and principles needed to design and predict the performance of real engineering systems and structures. The preparation of engineers for creative design should be kept always in mind. Creative design requires as much ingenuity, imagination, and resourcefulness in the application of physical laws and principles and making them useful to man as is required in the original formulation of them.

In order to solve real problems of the great variety and number that are presented to the engineer, it is necessary that he become proficient in a systematic method of problem solution. Consequently, instruction in methodology is an essential part of engineering mechanics. Instruction must include ample emphasis on the following operations which are basic to engineering analysis.

The student must learn to identify the essential elements and characteristics of each specific engineering problem. Is it, for example, one involving statics or dynamics, rigid or deformable bodies, a conservative or a dissipative system? He must be able to select relevant information and data and recognize those which are not pertinent. In doing this an ideal model must be created and the problem made amenable to solution. The results based on the idealized model must next be interpreted in the light of the original real situation. The engineer must form a judgment of the extent to which he can rely on the results obtained on the ideal model, and finally he must be able to communicate this to others in suitable and usable form.

The engineer must devote major emphasis to the formulation and evaluation of his problem quite apart from the necessary analysis. Instruction given the engineering student should reflect this fact.

It is in this spirit that the instruction in engineering mechanics assumes a significant role as a springboard to a truly professional attitude and approach to all engineering situations.

Objectives of Instruction in Solid State Physics

Before considering the place, if any, of solid state and nuclear physics in engineering curricula, it is desirable to consider the activities of physicists in these respective fields. In nuclear physics, the physicist is concerned with the quantitative behavior and structure of nuclei, the nature of forces involved between nuclear particles, and the interaction between nuclei and radiation. In solid state physics the physicist is seeking to develop an understanding of the properties of solids on the basis of their atomic constitution.

To take part in the current activities in either of these field requires a background and a working knowledge of quantum mechanics as well as of the general principles and conservation laws of classical mechanics and electrodynamics. Such knowledge can be obtained only through several years of study, generally including graduate work. This conference is convinced that there is no short-cut by which this knowledge can be given to undergraduate engineering students by

means of a one or two-semester course in modern physics.

On the other hand, an introductory course of one or two semesters' duration covering some of the topics mentioned above could be given following the general physics course. Such a course should broader the training of the undergraduate engineer.

It is the conviction of this conference that the time should not be taken from that now devoted to an understanding of the fundamental principles of mechanics, which should be required of all engineers. Instead, the conference recommends that the basic physics course be strengthened by greater emphasis on fundamental classical principles and conservation laws, and by an introduction to wave and quantum concepts. Inclusion of these topics is an essential introduction to the later study of solid state or nuclear physics. It is also recommended that as far as possible, such particles as electrons, protons and neutrons be used in the elementary physics course to illustrate general dynamical principles. In the case of existing two-year physics courses, it is the belief of the conference that some concepts of modern physics can be introduced without requiring additional time. In the use of one-year physics courses, an extension of time of at least a semester is recommended.

Mathematics Instruction as Related to Mechanics

It is urged that the concepts of calculus be introduced in engineering curricula as soon as possible, preferably in the freshman year, and used in physics and engineering as soon as feasible.

Conclusion

In comparing the different objectives and points of view of instruction in mechanics by physicists and engineers, it should be emphasized that the physicist uses problems and examples from experimental physics essentially for the purpose of developing by the inductive method those concepts and principles which it is his objective to have the student understand. The engineer, on the other hand, uses certain concepts and principles for the purpose of achieving the solution of practical engineering problems. This distinction should determine in a major way the essentially different character of illustrative material used in each area.

If instruction in physics and engineering mechanics follows the objectives outlined, it appears that, although some duplication of content is inevitable and even desirable, the real duplication in terms of influence on the engineering student will be negligible. On the other hand, if instruction in physics follows in any major way the direction of application to engineering situations, or if instruction in engineering mechanics fails to emphasize the professional engineering approach, then this duplication will result in a serious waste of time.

Consequently, it is evident that the preservation of the two different but mutually supporting points of view of the physicist and the engineer is a necessary condition for maintaining the progressive program of engineering education, which in these critical days is of vital interest to the entire nation.

Finally, the conference recognizes that progress occurs through continuing experimentation, and therefore recommends that such an attitude be encouraged in the teaching and the curricular arrangements of physics and engineering mechanics.

The participants in the conference were:

Dean J. W. Buchta, University of Minnesota
Prof. J. W. Cell, North Carolina State College
Prof. P. F. Chenea, Purdue University
Prof. W. L. Collins, University of Illinois
Prof. J. P. Den Hartog, Massachusetts Institute of Technology
Dean H. Fletcher, Brigham Young University

Prof. N. Frank, Massachusetts Institute of Technology
Dean L. E. Grinter, University of Florida
Dr. G. H. Hickox, National Science Foundation
Dean E. Hutchisson, Case Institute of Technology
Dean R. B. Lindsay, Brown University
Prof. J. L. Meriam, University of California
Prof. Glenn Murphy, Iowa State College
Prof. M. S. Plesset, California Institute of Technology
Prof. D. H. Pletta, Virginia Polytechnic Institute
Prof. J. J. Potter, Texas A. and M.
Prof. J. A. Sauer, Pennsylvania State University
Dr. Raymond Seeger, National Science Foundation
Prof. F. L. Singer, New York University
Prof. I. S. Sokolnikoff, University of Calif. at Los Angeles
Prof. W. B. Stiles, University of Alabama
Prof. D. Williams, Ohio State

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Report of Conference on Electricity and Magnetism in Engineering Education

A joint conference of the Electrical Engineering and Physics Divisions of A.S.E.E. has been agreed upon for the 1955 annual meeting Tuesday afternoon, June 21. The chairmen of the respective divisions, Professor J. N. Thurston, Head of the Department of Electrical Engineering at The Clemson Agricultural College, and Dr. R. J. Seeger, Acting Assistant Director for Mathematical, Physical, and Engineering Sciences of the National Science Foundation, envisioned the desirability of an invitational closed working conference to do the ground work for a constructive and informative program for the annual meeting. Dean L. V. Bewley, of the College of Engineering of Lehigh University, offered to organize such a working conference and was appointed chairman of a steering committee and chairman of the conference. The National Science Foundation agreed to sponsor the conference with the Executive Committee of A.S.E.E. and to defray the expenses of the conference.

Thirty-four electrical engineers and physicists met at Lehigh University February 7, 8, and 9, 1955, to discuss desiderata in instruction by electrical engineering and physics departments for undergraduates in electrical engineering and other engineering in view of the changing demands on engineering education. Appropriate prerequisite and concurrent mathematical instruction was also considered. The deliberations of the conference led to the assignment of various committees to formulate the collective attitudes of the conference in reports which were then revised and adopted by the conference. The following reports were adopted without dissent, with the single exception that one dissenter wished to go on record on one of the reports.

Objectives of Teaching Electricity and Magnetism in Engineering Education

The objectives of teaching Electricity and Magnetism in Engineering Education are:

(1) to teach fundamental principles from an overall scientific point of view, including their relationships to other types of physical phenomena, and

(2) to teach the application of these principles to the solution of engineering problems, including their relationships to other types of engineering.

Conceivably this might be done in a single department, but (1) is primarily in the province of physics and (2) is primarily in the province of engineering: hence complementary courses in these areas are highly desirable. In any case, it is evident that close and continued cooperation between the local physics and engineering departments is necessary for the successful attainment of these objectives.

Mathematics in the Basic Physics Courses

It is believed by this Conference that it is both possible and desirable for the fundamental concepts of the calculus—the derivative and the integral—to be introduced at an early stage in the curricula of engineering students. This introduction can be made simultaneously in physics and mathematics, thus re-en-

forcing the learning process. In this way the student should gain a deeper understanding of both mathematical and physical concepts. Calculus methods should then be used in increasing measure in succeeding portions of the basic physics courses.

If local conditions make it impossible for the department of mathematics to introduce the calculus concurrently with, or before, the first course in physics, it is recommended that certain concepts of the calculus be introduced in this physics course. It is suggested that this introduction be limited to conceptual matters, that is that it not be extended to include the derivation of a formal table of derivatives or integrals as this should be left for the appropriate course in mathematics.

The Conference further recommends that at least part of the basic physics courses—preferably electricity and magnetism—be taught with the calculus as a firm prerequisite.

As much of the mathematics as possible should be left in the hands of the professional mathematics teachers. In any event, the first two years of the mathematics courses should be so taught.

It is recognized that a major cause of difficulty and failure on the part of students in the beginning physics courses is the inadequate preparation which many of them have in high school mathematics. It is recommended that prerequisites in mathematics for engineering students be strengthened so that a minimum basis for admission into the freshman year will be adequate mathematical preparation through trigonometry.

Electricity and Magnetism in Elementary Physics for Engineers

It is recognized that the practice of engineering has come to require more and more complete knowledge of the basic laws and discoveries of pure science. Obviously then the importance of the basic training in the elements of the field of physics as a prerequisite to the professional training of engineers has increased likewise.

It is also recognized that many of today's methods in the technological application of the fundamental laws and facts may soon be obsolete. In other words, the specific nature of the engineering devices changes rapidly whereas the fundamental laws on the basis of which such devices were designed are timeless.

In recognition of this situation with respect to the enduring value of an understanding of basic principles, as distinguished from the temporary value of knowing the technical details of today's application, it is recommended that the general course in elementary physics for all engineering students be so given as to instill (1) a thorough understanding of the basic laws and principles, (2) the viewpoints found most useful in analyzing representative physical situations and (3) the application of the mathematical skills including integral calculus and elementary linear differential equations.

To this end the following outline suggests highpoints of the portion of a general course in physics that should be devoted to the study of Electricity and Magnetism. This course is visualized at approximately the sophomore level.

The outline is neither to specify the details nor the extent of the content, but *is for the purpose of illustrating the viewpoint* that is recommended in emphasizing the fundamental laws and illustrating their implications by examples, in such a way, and of such a sort, as to develop the student's ability to think clearly about these laws and to make effective use of the mathematical skills that are available to him for aid in such thinking. In this viewpoint, except for the laws and some of the basic characteristics of matter, *the facts are of secondary importance in relation to the ability to reason effectively concerning the implications of such facts.*

Outline of Highlights in Electricity

A brief resumé with respect to our current model of the electrical structure of matter.

Coulomb's Law, the concept of an electric field and the use of Faraday's electric flux concept particularly as expressed by the integral form of Gauss' Law. These expressions to be used in vector form along with the evaluation of the magnitudes in illustrative problems.

Illustrative problems, in general restricted to points, planes, spheres, and infinite cylinders.

The concept of a scaler potential, the conservative field, and the relation of the potential gradient to the previously defined electric field vector. In the introduction of the idea of potential and its relation to energy, it is believed feasible to introduce the utility of the vector dot-product in connection with the line-integral that expresses the potential difference between two points in an electric field. The elementary properties of idealized isotropic dielectrics and their effect on the potential difference between charged conductors in the simple arrangements represented by parallel plate, concentric spherical and concentric cylindrical capacitors.

The concept of an electric current, "free" electrons and the conductivity of metals, with the introduction of the concept of conductivity in connection with current density and electric field intensity, as well as the resistance of wires and other simple conductors, and the assumption of Ohm's Law.

Joule's Law, the concept of e.m.f., and the idea of the transformation of energy from some other form into electrical in a source of e.m.f. Then consideration of the energy stored in a capacitor, not only in terms of its charge and potential difference, but also in terms of energy per unit volume of its electric field.

Kirchhoff's rules, as basic concepts, rather than as techniques for the solution of networks. Such circuits as the potentiometer and the Wheatstone bridge as illustrations for the application of the ideas represented by Kirchhoff's rules.

The magnetic field, as a consequence or manifestation of the motion of electric charges in general. Ampere's Law as the basic statement (preferably in the form of the vector cross-product) of the magnitude and direction of the magnetic field related to moving charges as individual entities and as an electric current.

The magnetic field, in terms of the force on a charge moving therein (the Lorentz force) and likewise in terms of the force on a current carrying conductor in the magnetic field. Illustrative examples and problems from a variety of devices with the emphasis always on the fundamental laws rather than the utility or detailed operating characteristics of the devices.

Induced e.m.f., "motional" from the standpoint of the Lorentz force, as well as the more general situation expressed by Faraday's Law. The property of inductance as a consequence of Faraday's Law.

The general properties of idealized magnetic materials and some of the qualitative aspects of ferromagnetism, mostly as illustrated by the hysteresis loop. Ampere's circuital relation as a line integral embracing the magnetizing current in such simple cases as the toroid with and without an air-gap. In this connection, once again the concept of stored energy, this time in the magnetic field.

Simple circuits with inductance, capacitance, and resistance, and the simplest relationships in alternating currents.

Essential Points Concerning Upper Division Courses

Upper-Division courses should be based on, emphasize, and re-emphasize the physical principles of electricity and magnetism introduced in lower division work. Additively, the perimeter of mathematical knowledge and the appreciation of its value in electrical engineering should be expanded as demanded by: (i) those portions of the developing domain of physi-

cal science, which must be incorporated into a viable engineering curriculum, and (ii) the engineering applications thereof.

This desired expansion of mathematical knowledge could be given in a single systematic mathematical course or by inclusion in engineering courses as dictated by local conditions. Thus, Fourier series could be developed as needed for solution of periodic nonsinusoidal circuit problems, Laplace and Fourier transforms as needed for the solution of transient problems, conformal mapping as needed for static electric and magnetic field problems, vector analysis as needed for electromagnetic field theory; etc.

Work in upper-division electromagnetic theory ought to be expanded to include study of phenomena associated with other than strictly linear isotropic media to which current instruction is generally limited. In such connection it is desirable to include in the engineering curriculum a core content of the physics of matter from the modern point of view. This gives rise to the requirement for a book on solid state physics specifically directed to the needs and professional interests of the engineer.

Modern Physics and Properties of Matter

Physics seeks to understand nature; engineering seeks to utilize nature. However, in order to utilize nature properly one must also understand nature. Prior to about 1900, the electrical engineer was limited in his efforts to understand and control nature by the fact that the treatment of electric and magnetic phenomena had not advanced beyond the stage of the macroscopic methods of Maxwell. Since 1900 the development of modern physics including quantum theory, the theory of the solid state, nuclear physics and high energy physics, has provided a much broader base for the consideration of these phenomena. This new knowledge, in combination with the classical principles of electromagnetic theory, has permitted the engineer to create the new devices and components which have made possible recent developments in communication and automation. Thus the engineering student today must have an understanding of this new knowledge on the properties of matter, in order that he may contribute creatively to the technology of tomorrow and in order that he may improve the operation of present day devices by extending their frequency of operation, increasing their reliability, and providing for further miniaturization.

It is recommended, therefore, that in order to meet a real need brought about by developments of the last 50 years and to anticipate the developments of the next 50 years, the salient points of modern physics should be presented in a course to electrical engineering students as early as possible in their curriculum. It is believed by the committee that this course can be the same for all engineers and should be offered in addition to a course in general physics. The course content recommended in the report of the closed conference on nuclear physics in engineering education meets with the approval of this committee. This is as follows:

a. Atomic Structure of Matter
   Kinetic Theory
b. Fundamental Particles
c. Quantum Theory of Light
d. Atomic Structure
   1 Energy Levels
   2 Spectroscopy
   3 Periodic System
e. X-Rays
f. Wave Nature of Matter
   One dimensional wave equation
g. Atomic Nucleus
h. Molecular Structure
   Valence Bonds
i. Nuclear Structure—Elements, isotopes, elementary particles
j. Binding Forces
k. Binding Energy Curve
   1 Mass-Energy Curve
   2 Radioactivity
   3 Nuclear Reactions
   4 Fission, Fusion

1. Neutron Chain Reaction
   1 Heat—Power
   2 Radiation—Interaction with matter
   Radioisotopes
   Breeding
   3 Fission Products

It is further recommended that a course in the physical properties of matter should be available for election by electrical engineering students and that this course should present a phenomenological basis for understanding the characteristics of materials used in electrical engineering. Such a course might include the topics suggested by the Allerton Conference on Solid State Physics in Engineering, namely:

Crystal Structure
Binding Forces and Crystal Types
Mechanical and Thermal Properties
Electrical Conductivity
  (a) Metals
  (b) Semiconductors
  (c) Salts
Dielectric Properties
Magnetic Properties
Surface Effects
Prosphors and Photoconductivity

Modern Applications in Traditional Engineering Courses

In addition to strengthening the scientific foundation of engineering by the inclusion of "Modern" physics courses, it is important to point out applications in modern physics by illustrative material and problems introduced into pertinent existing courses in each of the conventional branches of engineering. This would include problems posed by the newer industries within the conventional engineering disciplines and the newer techniques which can now be applied in older industries.

As an illustration of the applications of nuclear physics in the field of electrical engineering, instrumentation studies may be considered. These should include the detection of the various nuclear radiations over a wide range of intensities, and as a part of the control system of a nuclear power reactor. This becomes a good example of a servomechanism. The radioactive thickness guage is a corresponding example of how a new technique can be applied as a process control in the older paper industry.

Need for Experimentation in Curricula

This conference, recognizing the many pressures for change in Electrical Engineering curricula, makes explicit its wish that no action taken by it shall be interpreted as discouraging experimentation by the universities in altering the content of courses, or in changing the location of courses within departments.

Cooperation to Meet Local Situations

The conference recognizes that the jurisdictions for the various functions implied in its recommendations must vary from one institution to another as indicated by local conditions. It strongly urges sustained contacts between the departments of physics and electrical engineering in each institution by such means as frequent conferences and exchanges of teachers and personnel on research projects. The understanding gained by such contacts should make it possible for faculties to develop optimum engineering programs with their local facilities.

Conference Members

L. V. Bewley, Lehigh University; W. B. Boast, Iowa State College; J. C. Boyce, Argonne National Laboratory; J. G. Brainerd, University of Pennsylvania; T. B. Brown, George Washington University; H. E. Hartig, University of Minnesota; V. P. Hessler, University of Illinois; G. H. Hickox, National Science Foundation; T. J. Higgins, University of Wisconsin; C. L. Hogan, Harvard University; J. H. Howey, Georgia Institute of Technology; V. A. Johnson, Purdue University; E. C. Jordan, University of Illinois; J. J. Karakash, Lehigh Univer-

sity; J. H. Lampe, North Carolina State College; W. A. Lewis, Illinois Institute of Technology; D. P. Mitchell, Columbia University; F. E. Myers, Lehigh University; A. O. Nier, University of Minnesota; L. O. Olsen, Case Institute of Technology; H. A. Peterson, University of Wisconsin; J. G. Potter, Agricultural and Mechanical College of Texas; E. Rogers, University of Alabama; E. R. Schatz, Carnegie Institute of Technology; W. M. Schwarz, Union College; R. J. Seeger, National Science Foundation; H. Semat, City College of New York; J. N. Thurston, Clemson Agriculture College; J. H. Van Vleck, Harvard University; H. W. Welch, Jr., University of Michigan; M. W. White, Pennsylvania State University; D. Williams, Ohio State University; J. Zaborszky, Missouri School of Mines and Metallurgy.

Conference Co-Secretaries,
J. G. POTTER
L. O. OLSEN

Thermodynamics in Engineering Education Conference

The Pennsylvania State University
June 27, 28, 29, 1955

A conference for thermodynamics teachers concerning certain aspects of thermodynamics, which are having an impact on engineering and engineering education, will follow the American Society for Engineering Education annual meeting at The Pennsylvania State University. Sponsored by the National Science Foundation and the American Society for Engineering Education, this conference continues the study of basic sciences in engineering. The program will include the following subjects:

1. Special industrial applications of thermodynamics.
2. All engineers need thermodynamics.
3. Thermodynamics and irreversible processes.
4. Irreversible coupled flows.
5. Electric and magnetic phenomena.
6. Electrochemistry.
7. Statistical thermodynamics.
8. Rate processes.
9. Relaxation phenomena.
10. Elastomer thermodynamics.

Further details about conference arrangements and the program can be obtained from Professor W. E. Ranz, Department of Engineering Research, The Pennsylvania State University, University Park, Pennsylvania. Registration is limited.

Physics in Engineering Education*

The National Science Foundation has granted the American Institute of Physics the sum of $13,600 to support a study and evaluation of the role of physics in engineering education. A committee to make the study has been appointed by the Institute as follows:

E. Hutchisson, Case Institute of Technology (*Chairman*)
L. B. Borst, New York University (*Secretary*)
J. W. Buchta, University of Minnesota
Dudley Chambers, General Electric Company
Hugh Dryden, National Advisory Committee for Aeronautics
Harvey Fletcher, Brigham Young University
W. V. Houston, Rice Institute
J. A. Hutcheson, Westinghouse Electric Corporation
R. B. Lindsay, Brown University
D. H. Loughridge, Northwestern University
H. V. Nehr, California Institute of Technology
Lloyd P. Smith, Cornell University
J. A. Stratton, Massachusetts Institute of Technology
William W. Watson, Yale University
Marsh W. White, Pennsylvania State University

The role of physics in engineering education has continually been under discussion. Recently such discussion has been intensified and has received the attention of a committee of the American Society for Engineering Education. The committee was asked to determine the patterns that engineering education should take to keep pace with the rapid developments in science and technology, and to educate men who will be competent to serve the needs of and provide the leadership for the engineering profession over the next quarter-century. It has now prepared and circulated an interim report including recommendations.

Another committee, sponsored by the American Association of Physics Teachers, has also considered this subject and wishes to develop well-founded views to exchange with the ASEE committee. The present AIP activity was undertaken at the request of the AAPT because it was believed that the interest and resources of the entire organization of physicists should be mobilized behind this enterprise.

A meeting of the AIP committee was held at Gould House of New York University on January 31 and February 1. As a result of a program adopted at this meeting, visits will be made to a number of institutions having engineering schools to determine the actual present role of physics in the engineering curricula and the objectives in the minds of those who teach it. The information and opinions gathered in this way will be digested and interpreted by the committee and its staff, and then presented in a report with recommendations. An opportunity to present an interim report will come at the joint ASEE-AAPT meeting June 20–24 at Pennsylvania State University.

* Reprinted from *Physics Today*, March, 1955.

Conference on Thermodynamics in Engineering Education

The following persons participated in the Conference on Thermodynamics in Engineering Education at Purdue University, Lafayette, Indiana, February 28 and March 1, 1955:

1. J. F. Bailey, University of Tennessee; 2. F. G. Brickwedde, U. S. Bureau of Standards and University of Maryland; 3. W. L. Collins, University of Illinois; 4. C. E. Cutts, National Science Foundation; 5. B. F. Dodge, Yale University; 6. W. C. Dunlap, General Electric Co.; 7. R. E. Fadum, North Carolina State College; 8. R. G. Folsom, University of Michigan; 9. N. A. Hall, University of Minnesota; 10. J. Halpern, University of British Columbia; 11. G. A. Hawkins, Purdue University; 12 G. H. Hickox, National Science Foundation; 13. J. H. Keenan, Massachusetts Institute of Technology; 14. R. A. Morgen, Purdue University; 15. R. W. Moulton, University of Washington; 16. E. F. Obert, Northwestern University; 17. W. E. Ranz, Pennsylvania State University; 18. W. Ross, Pennsylvania State University; 19. F. D. Rossini, Carnegie Institute of Technology; 20. I. W. Smith, University of Toronto; 21. J. M. Smith, Purdue University; 22. M. Tribus, University of California; 23. E. Walker, Pennsylvania State University; 24. M. W. Zemansky, City College of New York.

The relationship of thermodynamic courses to physics was discussed as well as the general status of thermodynamics teaching. As a result of these discussions the conference adopted the following resolutions:

1. Thermodynamics is a fundamental science which is a desirable element in the general and professional education of all engineers.

2. Although instruction of engineering students in thermodynamics is relatively highly developed, the attention of teachers of thermodynamics should be directed toward the newer areas of activity, such as irreversible thermodynamics and statistical thermodynamics.

Then the following decisions were made concerning the aims, objectives, and methods for conducting the forthcoming conference:

1. The open Thermodynamics Conference at The Pennsylvania State University should be aimed at young teachers of engineering thermodynamics.

2. Some of the material to be presented should illustrate the use of thermodynamics by industry and practicing engineers.

3. A discussion should be included to cover present practices in the teaching of mechanical and chemical engineering thermodynamics and trends.

4. The role of thermodynamics in curricula other than chemical and mechanical engineering should be presented.

5. The subject of heat transmission should be excluded from the conference program.

6. The subject of teaching methods and teaching aids should be excluded from the conference program, since this is the subject of one of the sessions of the 1955 ASEE annual meeting.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 29–30, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 7, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Swarthmore College	May 7, 1955	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	March 26, 1955	M. M. Jones, University of Missouri
*National Capital Area			J. C. Michalowicz, Catholic University
*New England			E. R. McKee, University of Vermont
*North Midwest			C. J. Pratt, Michigan College of M. and T.
*Ohio	University of Akron	May 7, 1955	K. F. Sibila, University of Akron
Pacific Northwest	University of Idaho	April 15–16, 1955	M. L. Jackson, University of Idaho
*Pacific Southwest			B. M. Green, Stanford University
Rocky Mountain	Colorado A. & M. College	April 16, 1955	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9, 1955	V. L. Doughtie, University of Texas
*Upper New York			B. H. Norem, Syracuse University

Members of the Society are welcome at all Section Meetings

* No date set.

THE T-SQUARE PAGE

CONTRIBUTIONS TO ENGINEERING EDUCATION

BY THE

DIVISION OF ENGINEERING DRAWING

T. T. AAKHUS, *Chairman*
University of Nebraska

WILLIAM E. STREET, *Vice Chairman*
A & M College of Texas

HAROLD P. SKAMSER, *Secretary-Treasurer*
Michigan State College

IRWIN WLADAVER, *Editor of*
the T-Square Page
New York University

Teaching Engineering Graphics Effectively for Today and Tomorrow *

By FRANK A. HEACOCK

Professor of Graphics, Princeton University

In our engineering colleges every student must learn the fundamental principles and useful applications of mathematics, chemistry, physics, mechanics, and engineering graphics. The comprehensive term "engineering graphics" includes not only the basic courses in engineering drawing and descriptive geometry but also the advanced graphics courses and important parts of other engineering courses that may be taught most effectively when graphic methods are employed. It is the purpose of this paper to point out the educational objectives of graphics instruction and to show in some detail how engineering graphics may be taught effectively to accomplish these objectives so that the engineering student will derive from it all of the benefits that are of value to him while he is in college and after he enters his profession.

Let us consider the student, the time available, the subjects taught, the instructor, and the problems involved in upgrading our courses. The student is our most important consideration, and his educational development demands our careful thought. How shall we make the best possible use of the limited teaching time available? Although the course content of engineering drawing and descriptive geometry is similar in most colleges, it does not conform to a standard pattern. These basic courses are being continually improved and new material is being added to keep pace with engineering developments. The instructor who is aware of current trends in his field and who is willing to change traditional teaching methods when a better procedure is found for developing the creative capabilities of the individual, will gain the interest and full cooperation of his students. In this paper I endeavor to bring into proper perspective these significant aspects of the graphics instruction picture.

Engineering drawing is the universal medium of expression for showing exactly how things are to be manufactured, or built, or accomplished in the industrial

* Presented at ASEE Annual Meeting, University of Illinois, June 1954.

world. For best results each drawing must tell its story clearly and completely. Therefore, engineering drawing is taught as a precise, graphic language which all engineers must learn to write and to read. A college course in engineering drawing has important educational values in addition to the production of satisfactory drawings. We should consider technical sketching, reading drawings, fitting the course to the students' ability, the true meaning of skill, and the best way to budget the teaching time available.

Facility in technical sketching is regarded as an essential part of the engineer's working equipment, and it is our job to teach the student how to make quick, effective sketches. Requiring no special talent, the ability to make good sketches is the result of careful, persistent practice under the guidance and encouragement of the drawing instructor. Experience has shown that students make rapid progress in learning the principles of projection drawing while making multiview sketches of simple machine parts on cross-section paper at the beginning of the course. The sketch introduces the student to a natural way of expressing on paper his mental image of the object when it is viewed from above, from in front, or from the side. As it provides a convenient means of portraying his constructive thoughts, the sketch promotes the habit of exact thinking, careful observation, and correct mental vision. The student finds his ability to sketch a useful aid to learning not only in the drawing course but also in mathematics and physics. The importance of technical sketching requires greater emphasis on freehand work throughout the course in engineering drawing.

Learning to read drawings is just as important as learning how to draw. To interpret an engineering drawing and form in the mind a correct, complete picture of the object represented is a stimulating exercise in constructive thinking. It involves accurate observation, progressive visualization, and a thorough mental grasp of each detail in its true relation to other details and to the whole object. A multiview drawing cannot be read by looking at one view. The student must imagine himself moving around the actual object and looking at it in the direction each view is taken. This nimble mental shift from one viewpoint to another excites the imagination. The new facts discovered at each viewpoint build up the mental picture until it becomes a complete realization. Many carefully selected exercises of progressive difficulty are needed to develop facility in reading drawings. Useful for this purpose are completion problems that require a new view of an object in proper relation to the given views. Other good exercises include the missing line problem and the possible view problem. The combination of reading exercises and technical sketching is especially helpful in frequent quizzes throughout the drawing course.

In our search for better ways to teach engineering drawing we must be sure to fit the course to the needs and capabilities of the student. Although it would be helpful to count on effective drawing instruction in high school, many of us have learned from experience that it is best to start at the beginning and not to assume that the student who made drawings in high school has a good working knowledge of the fundamental principles of projection drawing. In an average class of 25 freshmen most of them respond quite readily to instruction and make encouraging progress. A few students do exceptional work, producing drawings that may be displayed as examples of superior drafting. On the other hand, there may be one or two who simply cannot learn to draw. After slow and clumsy effort, their completed drawings are usually not acceptable, and they make a poor showing on tests and examination. We sometimes wonder how they managed to pass the engineering aptitude test. This wide range of natural ability makes it difficult to set a proper pace for the class. The individual who is capable of rapid prog-

ress and who has acquired a certain proficiency in drawing should not be held back or allowed to mark time. The remedy suggested for this situation is to section students according to ability in order to set a proper pace for each group and to allow each individual to develop to his highest level of creative thought and skill in graphic expression.

In the Preliminary Report of the ASEE Committee on Evaluation of Engineering Education the statement is made in reference to engineering drawing that "its value as a skill alone does not justify its inclusion in a curriculum." I doubt that any college course in engineering drawing has either the time or the intention to develop manual expertness in drafting. But skill in a broader sense is a worthwhile objective of the drawing course. The true meaning of skill is the ability to use one's knowledge effectively. Engineering drawing provides a systematic procedure for organizing productive ideas and expressing them on paper in an accurate, unmistakable manner. This graphic habit of thought and expression which the drawing course aims to develop is a valuable skill that the engineering student will often use to advantage.

Time-Saving Methods

In many colleges the time allotted to engineering drawing has been reduced to the point where it is difficult to cover essential material and teach the course effectively. In trying to budget the limited time available one is forced to consider time-saving methods of instruction. Workbooks of printed problem sheets have been widely adopted, in spite of their limitations, because they allow the student to cover two or three times as many problems during the course. Another way to save time is to reduce the number of problems and eliminate repetition by selecting problems that combine several features of instructional value to the student.

More efficient use of time could be gained by teaching the principles of dimensioning along with shape description from the beginning of the course. A multiview drawing without dimensions is like a bird without wings. After the principles and methods of simple dimensioning are applied to elementary problems, the special practices and notes referring to typical shop operations can be gradually introduced when appropriate problems are assigned. Experience has shown that this parallel treatment of shape and size description saves time and gives good results. In some large industries there is a definite trend toward simplified drawing and dimensioning practices which could well be reflected in drawing courses by the gradual adoption of sound methods for eliminating nonessentials and needless repetition of details. This would also save much valuable time on the drawing board.

Turning now to descriptive geometry, we find this basic engineering course under fire by those who do not appreciate its educational values. At some colleges having ROTC programs students are allowed to drop descriptive geometry to make room for a required military, naval, or air science course. In a few schools department heads who do not consider that descriptive geometry is necessary in their field of engineering have omitted the course from their curriculum. In view of this situation and its implications for the future, let us reappraise our objectives, plan the best possible use of our potential resources, and chart a safe course into the probable developments that lie ahead. In my judgment there is a significant trend away from the representational and disciplinary phases of descriptive geometry and toward its versatile applications as an analytical tool through the full utilization of vectors, graphs, and diagrams. As the foundation of graphical science it can be developed into a cogent force for good in engineering education.

At the beginning of the course our chief concern is to give each student a thorough

grounding in the fundamental principles of descriptive geometry. These principles and methods are easy to grasp and to apply. The common sense approach of the auxiliary view method appeals to the practical mind of the engineering student. This novel method of attack arouses his interest because it opens up an entirely new line of thought that is in itself most valuable. The importance of the strategic direction of sight and the clever use of the end view of a line and the edge view of a plane capture his imagination. He is impressed by the geometric validity of a graphic solution that checks itself. When explained in proper sequence it is easy to establish the sound principles of descriptive geometry.

The only effective way to learn descriptive geometry is to work out diligently on the drawing board a series of carefully selected problems that embody all of the essential principles. Students often make the mistake of trying to memorize the mechanical operations of the graphic solution without thinking the problem through beforehand. A special effort should be made to encourage correct study methods and to ensure individual work on problem solutions.

For many years increasing emphasis has been given the useful engineering applications of descriptive geometry. One of its early uses was stereotomy, which is the science of stone cutting for arches, domes, and cloisters. Later applications included the graphic solution of problems encountered in structural steel details of hip and valley roofs and skew bridges, geology and mining problems, intersection and development problems in sheet metal structures such as penstocks and draft tubes, air conditioning ducts and ventilating systems, and lofting of surfaces for ships and aircraft. A wide variety of useful applications of descriptive geometry enriches the course, promotes student interest, and makes the teaching more effective.

As engineering drawing and descriptive geometry are closely related and each helps the other, sixteen engineering colleges have found it desirable to combine them in a single basic course which might be called engineering graphics. In order to do more work in less time and teach all of the essential material more effectively the two subjects should be securely joined together to preserve continuity and unity of purpose. The common bond of orthographic projection which is the sound basis of both subjects permits consolidation and a substantial saving of time. Judicious rearrangement of course content produces further economies by avoiding overlapping of topics and needless repetition. Some drawing courses contain problems involving intersection and development which properly belong in the descriptive geometry part of the course. Also certain parts of pictorial representation may be presented to better advantage as applications of descriptive geometry. A true dovetailing of the various elements of the two subjects must be achieved by efficient reorganization of essential material in a logical sequence so that each new phase is properly correlated with preceding principles and methods. Real integration of engineering drawing and descriptive geometry in an effective basic course in engineering graphics appeals to a good many forward looking teachers in our field.

Engineering students must acquire a working knowledge of vectors because the vector principle is widely used in engineering. Vector analysis is a branch of mathematics, but the graphic approach is often preferred. Whenever vector problems involve three dimensions, the methods of descriptive geometry are used to advantage. Therefore, a basic course in engineering graphics should include adequate treatment of vector geometry. This should not be limited to concurrent forces or static conditions, but contain problems dealing with motion, time, velocity, acceleration, and couples due to nonconcurrent forces. The required courses in mathematics, physics, and mechanics which the engineering student is

taking at the same time, or will soon start, now put greater emphasis on vectors and their manifold applications. Thus the graphic solution of vector problems provides a convenient means of coordinating descriptive geometry with other courses in the engineering curriculum. This graphic approach clarifies many difficult problems that the student encounters in other courses and it gives him a better grasp of basic relationships. Consequently, it enhances his opinion of the value of graphics training as a dependable aid to the learning process.

Graphics As An Analytical Tool

Descriptive geometry provides an excellent introduction to the study of graphics as an analytical tool. Based on logical reasoning and the sound principles of space geometry, it puts into practice the engineer's methods of thinking each problem through to a successful and accurate solution on the drawing board. It teaches the student how to size up a problem from any desired angle and to consider possible methods of attack. After weighing the advantages and shortcomings of each method for solving the problem, he is able to use good judgment in selecting the best procedure. The continued use of graphic methods as a companion to analytical thought imparts self-reliance, resourcefulness, and initiative. Thus the study of descriptive geometry helps the student develop the keen, practical insight that is essential to advanced work in graphic analysis.

Many colleges have courses in advanced engineering drawing which are required for students in certain branches of engineering. In these courses the principles of projection drawing and dimensioning are applied to planning, sketching, and production of working drawings that conform to accepted standards of good practice in industry. As an understanding of shop operations is essential, lectures, demonstrations, and visits to the shops usually supplement individual instruction in the drafting room. In most cases the course content is adapted to suit the specific needs of students enrolled in the different departments of engineering. This setting offers a favorable opportunity to introduce various drawing projects involving some empirical design, which will challenge the ability of the engineering student. Here also is a good place to teach the principles and methods of representing facts, figures, trends, and performance by means of graphic charts. It is essential that the engineering student gain a working knowledge of this important means of recording and communicating information through actual design and construction of both technical and popular charts.

Advanced graphics is usually taught in an elective course at the junior or senior level. This course provides instruction and practice in graphical analysis of advanced problems and graphic methods of computation. The subjects covered may include graphical mathematics, graphic methods of determining empirical equations from experimental data, application of vectors to a wide range of force and motion problems, and design and construction of nomographs and other calculating charts. Many colleges have a senior level course in engineering analysis that is designed to help the student set up an engineering problem so that it can be solved by calculus. Sometimes the mathematics is so involved that the student has difficulty in grasping the method of solution, and the graphic approach is used to clarify the procedure. Here is an opportunity to assist the student when he needs the kind of aid that graphic methods provide. Let us devote our best efforts to organize and teach top-level courses in advanced graphics that will be most effective in developing the creative talent of the engineering student to its highest capability.

Occasionally a colleague who is teaching a junior or senior course complains that a few students in his class do careless drafting, or make faulty sketches,

or show scant knowledge of graphic methods. When we check back we find that the same students did creditable work in the drawing course. Unfortunately some individuals stop trying when quality standards are relaxed. This emphasizes the need for full cooperation by all faculty members in insisting upon high quality work whenever student drawings, sketches, or graphs are required in their courses, because employers of our engineering graduates demand it. For best results in this direction we should do some helpful missionary work among our colleagues.

This leads to another worthwhile purpose. If we convince a teacher of the value of the graphic solution for clarifying a difficult problem and for checking the result obtained by the usual mathematical solution, he will give the graphic method a trial in his course. Naturally the graphic procedure must be properly explained at the blackboard and the student must be required to work out an accurate graphic solution on the drawing board. Then the graphic method will sell itself to teacher and student because of its inherent advantages. As the graphic approach proves its educational value its use will spread to other technical courses to strengthen the role of graphics in engineering education.

Opportunities in Research

There are many opportunities for the teacher of engineering drawing and descriptive geometry to apply his talents to the solution of problems that arise in research projects in science and engineering. Many of us would like to undertake a graphics research assignment and we ask only a proper introduction to this purposeful effort. One can make a useful start by acting as advisor to graduate students who are working on thesis projects and by assisting colleagues who are engaged in research. This experience in setting up research problems and solving them by graphic methods often leads to the discovery of unsolved problems that challenge our best efforts. Let me urge you to engage in fundamental research. Your Committee on Advanced Graphics is willing to offer suggestions and assistance if desired. Many research projects in engineering and science need your proficiency in applying graphic methods to their problems. In return this rewarding experience will make your teaching of engineering graphics more effective for today and tomorrow.

CANDID COMMENTS

Student-Centered Review, and Rationalized Exams

By ROBERT B. DAVIS

Assistant Professor of Mathematics, University of New Hampshire

1. "Non-Directive" Review

In several of my calculus sections I have found myself with a couple of weeks free time at the end of the semester. The natural use for this free time was to spend it reviewing for the final examination, and we did this, using a rather definitely "student-centered" or "non-directive" approach—that is to say, the instructor did *not* run the show. After suggesting a review, the instructor sat back and let the class decide what to do next. Class response was eminently satisfactory, and a reasonably organized procedure quickly evolved. Students selected problems, volunteers went to the board and solved the problems with the assistance of the rest of the class—and the instructor sat in silence and watched. Class interest and participation were unusually high—aided, no doubt, by considerable relevant and good-natured heckling from the audience. The value of this kind of approach seemed considerable.

There has been a good deal of interest in introducing such a "student-centered" approach more widely in engineering education. (This is often called by other names, such as "non-directive," "group dynamic," or "permissive." I am not trying to make any sharp distinctions of language here.) We might cite the various items in the bibliography, in this connection.

However, many faculty members have considered the matter, and have felt reluctant to trust in a method which appears to leave so much to chance, and appears to frustrate the students' frequent desires to be dependent, or to be told just what is expected of them—or even to get as much help as they would like. Some have felt that the demands on the students' maturity are excessive (not to mention the demands on the instructor's self-control).

Leaving a free space in the schedule for two weeks of non-directive review preceding final exams may offer a means of overcoming some of these objections. At this time student motivation is unusually high. The class members know one another and know the instructor. Also, they have considerable familiarity with the subject matter by then. The circumstances seem unusually favorable for a group-dynamic approach. This is, in fact, the period when the student should be organizing his knowledge in his own mind, and should become especially active in contrast to his earlier passive dependence upon the instructor's efforts at organization.

Does this point toward a possible extension of non-directive methods?

2. A Rationalized Examination Program

There is a second point that has recently come to my attention.

As I have looked over various examination procedures, I have been struck by the rather basic errors that are frequently made in setting and grading exams. Basic errors, that is to say, in the sense of precise scientific measurement. Some schools give failing grades to many students who do not appear to deserve them—if, indeed, anyone ever does "deserve" them.

These errors are familiar in economics as double counting, in statistics as neglecting higher moments of distributions and failure to note trends, in physics as problems in quantization, and as stability of data, and in mathematics as non-linear scale shifts and as the addition of unlike units—adding apples to bananas. We set an exam in which five points in one problem are very hard to get, whereas thirty points in another come quite easily. These points have quite different meaning. Nonetheless, we add them all together and consider only the sum. In doing this we neglect the fact that a certain item—not necessarily important in general—may have appeared in three or four different problems and may have been counted far more than was consciously intended. We average together a sequence of exam grades, and all too frequently make no allowance for the difference between what a student knows in June, and what he knew last March. We then interpret this on a highly non-linear scale, where the first sixty points don't count for much individually, but one or two points from 60 on up may make a lot of difference. Then we quantize this into letter grades, where 70 equals 79, but 79 is not nearly equal to 80. In all of this process we customarily wreck havoc with the ordinary notions of significant figures. I have often seen students failed on the basis of 10 points out of 800, which seems to me to be an insanely optimistic view of the accuracy of tests as measuring instruments.

In all of this our basic philosophy seems to be that, if only we average together *enough* irrelevant data, at some point it becomes not only relevant but surprisingly precise.

The question is, can we do any better? I say yes, as a matter of fact, we can. We can make a direct relation between what the student does and what we want to ask of him. Specifically, we can determine a set of techniques, concepts, etc., which we consider the minimum. If the student shows reasonable mastery of this material, then we agree to take him along into the next term's work, and we guarantee him at least a passing grade. In a first term calculus course, for example, this might conceivably be a few fairly simple differentiation problems, and perhaps one or two easy word problems. In any event, I am skeptical of the value of requiring students to repeat a term's work, and it seems to me that this minimum material should be kept at a fairly simple level, with liberal allowances for minor numerical mistakes.

Similarly we can add several sets of progressively more difficult material, to determine which students should get C's, B's, or A's. But in no event do we add up total scores, for we do not want a brilliant piece of work on a difficult example to be obscured by a minor numerical error in one of the trivial problems. If a student can do most of the A material, he gets an A. In this way, each letter grade achieves a qualitative meaning; a B, for example, means that the student can handle the fairly difficult parts of the course, but not the most difficult ones. This seems to me a considerable improvement over the vague meaning which a B tends to have at present, compounded as it is of a long string of doubtful arithmetic operations, which assuredly are not even commutative.

Of course, the question of grades, and of failing students, goes much deeper than this. I suspect we should rely a good deal more on the instructor's judgment than most schools are willing to. Doubtless we shall someday have a more helpful treatment for failing students than our usual technique of intimidating them, implying to them that they personally are not up to standard, and requiring them to repeat the term's work. But I offer this grading procedure as an interim measure. It would work far less injustice than the unreasonably rigid (and irrational) systems still widely used at present.

We certainly need to learn to think in broader and more fundamental terms. Nonetheless, grades—and especially failing grades—are deeply interrelated with important basic issues. As a further example, I might note that excessive penalties for minor errors may so cancel excellent work elsewhere on an exam that it sometimes becomes nearly impossible for a student to earn a grade of A. This can speedily create an atmosphere of fatalism or resignation, and the atmosphere or general attitude among the student body is one of the most basic matters in any university.

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Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

EAST ASSISTANT PROFESSOR OF Metallurgical Engineering desired for September, 1955, with emphasis on heat transfer, thermodynamics, and physical chemistry. Advanced degree essential, experience desirable. May-1.

CHEMICAL ENGINEER TO HEAD Chemical Engineering Department of Young Four Year State College, Doctorate Essential. Salary for twelve months. Open. Address Dean, Lamar State College, Beaumont, Texas.

INSTRUCTOR OR ASSISTANT PROFESsor to teach engineering drawing and descriptive geometry. Engineering degree and teaching experience desired. Opportunity to do graduate work. Rank and salary dependent on education and experience. Appointment beginning September 15, 1955. Write J. D. McFarland, Chairman, Department of Drawing, The University of Texas.

CHAIRMAN OF CHEMICAL ENGIneering Department in accredited Eastern college; to administer undergraduate program and organize graduate program. Ph.D. preferred. Give teaching, research and industrial experience. Must be available for September, 1955. May-2.

POSITION OPEN TO TEACH DRAWING and Mechanics, Dept. of Engineering Mechanics, University of Nebraska. Rank and salary based on applicants' qualifications. Write inquiries to E. J. Marmo, Chairman of Dept., Lincoln, Nebraska.

INSTRUCTOR IN ELECTRICAL ENGIneering beginning September 1, 1955. One interested in teaching fundamental electrical engineering subjects. Salary depends on qualifications. Opportunity for advancement. New building and equipment. Apply to, Chairman, Department of Electrical Engineering, University of Nebraska, Lincoln 8, Nebraska.

ASSISTANT PROFESSOR, COMMUNIcations, Electronics. Real opportunity for young Ph.D. interested in both teaching and research. Rapid advancement possible for man with initiative and ability. Write: Chairman, Division of Engineering, Brown University, Providence 12, R. I.

TEACHING POSITIONS OPEN IN FOLlowing Fields: Electrical Technology: Mechanical Technology; Construction Technology. Must have B.S. degree in specific field, industrial experience in field desirable. Salary ranges: Junior Instructor $4080.00 to $4680.00; Instructor $4800.00 to $6000.00, starting level dependent upon education and experience. Applicants must be qualified to teach major and related subjects. Hudson Valley Technical Institute, Troy, N. Y. (Unit of The State University of New York).

CHEMICAL ENGINEER FOR HEAD OF Chem. Engrg. Department and Director of Research in accredited Engineering College. Must have doctor's degree. Research and teaching experience essential. Metropolitan New York. Appointment effective September, 1955. May-3.

ASSISTANT PROFESSOR OF ENGINEERING Mechanics open September, 1955. Doctor's degree with major in mechanics, or fluids, and with a strong minor in applied mathematics desired. Teaching experience and publications important. Younger man with Master's degree desiring opportunity for advanced study may be considered at the Instructor level. Apply to Prof. G. N. Cox, Chairman, Department of Engineering Mechanics, New York University, New York 53, N. Y.

ENGINEERING TEACHING POSITIONS in the Civil and Electrical fields are available at Fresno State College. Young men are preferred. Instructor and Assistant Professor positions open. Entire new campus under construction, including engineering. Excellent salary scale. Apply Dean A. R. Lang, Fresno State College, Fresno, California.

INSTRUCTOR—FOR DRAWING, FRESHmen Engineering Problems, Mechanics. Branch immaterial. Beginning in September. Salary determined by qualifications. Nine months per year. Apply to Dean of Engineering, Colorado A & M College, Fort Collins, Colorado.

INSTRUCTOR IN GENERAL ENGINeering, to teach engineering drawing and descriptive geometry. Engineering degree required. Appointment to begin Sept. 1, 1955. Send application to: C. I. Carlson, University of Illinois, Rm. 147, Navy Pier, Chicago 11, Illinois.

PROFESSORIAL POSITION OPEN ON the faculty of the Department of Electrical Engineering of Northwestern University. Faculty rank and salary will be determined upon the qualifications of the applicant selected. Position starts in September, 1955. A Ph.D. degree is desirable, but not necessary, if the applicant has a sufficiently strong research and publication record. May-4.

OPENINGS IN THE COLLEGE OF ENgineering of West Virginia University Beginning September 1955: AERONAUTICAL ENGINEERING: *Associate Professor* to teach aerodynamics. Ph.D. is required. Salary $6000 for nine month school year. CIVIL ENGINEERING: *Associate Professor* to teach undergraduate and graduate courses in structural design, intermediate structures, reinforced concrete and foundations. Ph.D. and experience desired. Salary up to $6000 for nine month school year. *Instructor* to teach surveying, fluid mechanics and other undergraduate courses. Master's degree or post-graduate experience required. Salary up to $4500 for nine month school year. ELECTRICAL ENGINEERING: *Instructor* or *Assistant Professor* to teach A.C. circuits to undergraduate electrical engineering students and elementary theory to non-electrical students. M.S. degree preferred. Experience will determine rating. Salary up to $5000 for nine month school year. INDUSTRIAL ENGINEERING: *Instructor* to teach industrial organization, motion and time study, production control and engineering economy. BSIE or BSME (Industrial Option) is required. Man appointed may work towards M.S. degree. Salary $4300 for nine month school year. MECHANICAL ENGINEERING: *Instructor* to teach engineering drawing, descriptive geometry and mechanism. BSME is required. Man appointed may work towards M.S. degree. Salary $4500 for nine month school year. *Assistant Professor* to teach thermodynamics, heat engines and mechanical laboratory. MSME degree is required. Salary $5300 for nine month school year. MECHANICS DEPARTMENT: *Instructor* to teach statics, strength of materials and kinetics. B.S. degree in any accredited engineering curriculum is required. Salary $4000 for nine month school year. *Assistant Professor* to teach statics, strength of materials and kinetics. M.S. degree in any accredited engineering curriculum is required. Salary $5000 for nine month school year. Applications for these positions should be sent to Dean R. P. Davis, College of Engineering, West Virginia University, Morgantown, W. Va.

Minutes of Executive Board, Knoxville, Tennessee, April 15, 1955

A meeting of the Executive Board of the ASEE was held at Knoxville, Tennessee on April 15, 1955 at 10:00 A.M. *President* N. W. Dougherty presided. Those present were *Vice Presidents* W. L. Everitt, B. R. Teare, Jr., L. J. Lassalle and H. K. Work; *Treasurer* G. W. Farnham and *Secretary* W. Leighton Collins.

1. *Report of the Secretary*

a. A lack of satisfactory space in any of the engineering buildings at the University of Illinois resulted in the University transferring a campus residence to the College of Engineering and making it available for the Society headquarters. The offices are all located on the first floor. The University allocated $2800, in addition to the loss of rent, to adapt the space to ASEE use. The University maintains the building and grounds, but asked the ASEE to pay for the utilities. The University also will furnish space and equipment for the Editorial Secretary.

b. Most of the newly ordered furniture has been received. It matches the old and the total cost to date is about $1200.

c. The office staff consists of Mrs. Naomi Garman, Office Secretary; Mrs. Louise Chambliss, Membership Secretary; and Mrs. Dorothy Sams, typist.

d. The Executive Board *voted* approval of a utilities item on the books to take care of routine janitor service, heat, light and gas. The secretary estimated the cost would not exceed $700 per year.

e. The Secretary explained the reasons for selecting the First National Bank in Champaign as the depository for the checking account. The Executive Board *voted* approval of the selection.

f. The Secretary stated the bonding company now bonds positions and not the individuals holding them. The Executive Board *voted* approval of the bonding and the payment of a three-year premium in order to save one-half of a year's premium.

g. The Executive Board *voted* to insure the furniture and equipment but not the society records. For the protection of the latter the Executive Board *voted* approval of the purchase of a fire-resistant filing cabinet.

h. The Executive Board authorized the President to express the appreciation of ASEE to Carl Muhlenbruch and his committee for their fine work in compiling and editing the Educational Aids Manual. Mr. Muhlenbruch is requested to submit a report to the Executive Board at its June meeting covering such matters as the future work of the committee, its finances, etc.

i. It was agreed a President's News Letter should be prepared and mailed prior to the Annual Meeting.

j. The Executive Board authorized the Secretary to exceed the budgeted amount for his travel by a reasonable amount if it became necessary. It was agreed President Dougherty should represent the Society at the inauguration of former Secretary A. B. Bronwell as President of Worcester Polytechnic Institute.

k. The attendance of EUSEC guests at the Annual Meeting was discussed. Since only about four or five were planning to attend, it was agreed Vice President W. L. Everitt should contact Dean F. M. Dawson and arrange the details whereby the cost of room, board, and registration while attending the Annual Meeting would be paid for by ECAC.

2. *Report of the Treasurer*

a. The Treasurer briefly reviewed the third-quarter report and answered sev-

eral questions regarding income and expenditures.

b. The Secretary stated a revised second-quarter report accompanied the third-quarter report in order to have an agreement between the December 31st audit, accompanying the change in Secretary, and the second-quarter report.

c. The life membership fund of the constitution was discussed and it was agreed Section 4, Article II should be referred to the Constitution and By-Laws Committee for study. The Executive Board *voted* that the life membership provision of the constitution, Section 5, Article II, should be interpreted as "a total of 25 years of membership in good standing" and not a continuous period of membership of 25 years.

3. *Reports of Vice Presidents*

Vice President W. L. Everitt, ECAC, reported that the program for their General Session at the Annual Meeting was complete. A discussion of council officers led to the agreement that the officers of ECAC and ECRC need not be the official representatives of their institutions but must be members of ASEE.

Vice President H. K. Work, ECRC, used the minutes of the last meeting of the Executive Committee as the basis of his report. Major items covered were that the Review of Current Research is about ready for publication and all orders should be forwarded to ECRC; that next year's budget was being prepared and requested the Secretary to consult with former Secretary A. B. Bronwell and Dr. Renato Contini, Secretary of ECRC, regarding its preparation and the ECRC reserve fund; and that the preparation of the needed book on creativity is progressing.

Vice President L. J. Lassalle, Divisions and Committees, reported briefly and stated that he spoke on Society activities at the meeting of the Missouri-Arkansas Section.

Vice President B. R. Teare, Jr., Sections and Branches, reviewed plans for attending Section meetings. It was agreed it was desirable for members of the Executive Board to attend Section meetings and appear on the programs when requested.

4. *Report of the President*

President N. W. Dougherty reported on the program arrangements for the General Session on Tuesday morning. Dean L. E. Grinter will be on the program for about 25 to 30 minutes, following the recess, to present the Final Report on Engineering Evaluation. He will be followed by Dr. E. S. Burdell who has been allotted about 45 minutes to make a preliminary report on the Humanistic-Social Research Project.

5. *Annual Meeting*

a. The Secretary reported that there were only two conflicts with the morning General Session, one each with ECRC and ECAC.

b. The Secretary reported the final copy of the report on Engineering Evaluation should be available by May first. It was agreed the Secretary should discuss publication with Dean L. E. Grinter. It was further agreed that free copies should be distributed at Penn State; that the entire report be included in the JOURNAL OF ENGINEERING EDUCATION; and that the future selling price should be based on the cost of printing and handling.

c. The Secretary reported that the Humanistic-Social Research Project would have a short printed report available for free distribution at Penn State. The committee is handling the printing and cost is being charged to their account.

d. The Secretary raised the question of a realistic budget for the Annual Meeting. It was agreed that a budget should be submitted by the host institution and the Secretary was instructed to have Penn State submit their budget.

e. It was agreed to permit the Physics Division and AAPT to jointly sponsor an exhibit of Physics books at the Annual

Meeting if there is adequate space. The control of the exhibit is to be in the hands of the Division and AAPT and they should have a strong committee handling it. The Secretary reported AAPT to be willing to pay all expenses in connection with the exhibit.

f. It was agreed the Secretary invite Robert Roy to present the ETS project, Progress Report of Findings from Testing of Experienced Junior Engineers, at the Monday General Session.

g. (Added to agenda.) Professors L. A. Rose and J. A. Reed, the two most recent local chairmen, reported their progress in preparing the Annual Meeting Guide. They were instructed to prepare 100 copies and have them available by the time of the Annual Meeting at Penn State.

6. *ASEE-NSF and other Conferences*

a, b, c, d. The Secretary stated the reports of the closed conferences on Engineering Mechanics, Electricity and Magnetism, and Thermodynamics will appear in the forthcoming issues of the JOURNAL OF ENGINEERING EDUCATION. The same is true of the report of the joint committee of ASEE and MAA on the Teaching of Mathematics to Engineers.

e. The Secretary reported that the Evaluation Committee suggested the RWI Committee assume the problem of discussing the Evaluation report with representatives from industry and have a frank and open discussion of the report at a future meeting; it was deemed undesirable to confer with representatives of one corporation only.

f. The Secretary reported all members of the Executive Board had approved the cooperation of the Society with Lehigh University and the AISC in sponsoring the Short Course on Plastic Design in Structural Steel to be held at Lehigh University September 7–15, 1955. The ASEE has no financial responsibility, now or in the future. Lehigh had been informed of the decision.

7. *Conference on Theoretical Engineering*

The Secretary read a letter from F. C. Lindvall indicating that the drafting of a program soon would be complete. The letter was the basis for having Dean Lindvall report to the Society at its Monday afternoon General Session.

8. *Graduate Study Project*

The Secretary reported on the status of the Graduate Study Project. The Executive Board instructed the Secretary to get from the committee a well developed program and a total budget for whatever number of years the project was to cover, the program and budget then to be submitted to the Executive Board for approval. It was agreed that funds for the study should be solicited by the Society.

9. *Publication of Reports*

a. Final Report on Evaluation of Engineering Education—covered in Item 5b.

b. Preliminary Report of Humanistic-Social Research Project—covered in Item 5c.

c. Nuclear Engineering papers presented at the Northwestern University Conference—several possible procedures were discussed, an extra issue of the Journal of Engineering Education receiving the most favorable comments. It was agreed the Secretary should discuss the entire matter with the retiring and newly-appointed editors. It was believed that about 10,000 copies should be printed and that the sale price should be sufficient to cover the expense of printing and handling the extra copies. The committee is believed to have about $2000 for printing the report.

10. *Appointment of L. A. Rose*

a, b. The Executive Board *voted* that L. A. Rose of the University of Illinois be appointed Editor and Director of Public Relations, effective July 1, 1955, in accordance with the terms previously agreed upon. The Executive Board also *voted*

that advertising be handled by the Editor and Director of Public Relations. (Dean W. L. Everitt did not participate in the voting.) In addition, the Executive Board *voted* that an Editorial committee of five be appointed by the President, the Editor and Director of Public Relations being an ex-officio member of the committee. Thus, there will be an advisory committee to work with the Editor and Director of Public Relations for each aspect of his duties, editing of the JOURNAL OF ENGINEERING EDUCATION and the handling of public relations.

11. *Resolutions of Appreciation*

The Executive Board *voted* that the Secretary write to Professor C. E. Watson, retiring Assistant Secretary and Miss Marion Strohm, retiring Office Secretary, expressing the deep appreciation of the Board and the Society for their highly commendable services during their years of association with ASEE.

12. *Termination Pay*

The Executive Board *voted* to grant Miss Marion Strohm, retiring office secretary, three weeks termination pay.

13. *Social Security*

The Executive Board *voted* to pay for Social Security at such time the office staff expressed the desire for coverage.

14. *Relation of YET to ASEE at National and Local Levels*

The letter from Henry H. Armsby to A. B. Bronwell dated 13 Jan. 1955 was read and after considerable discussion it was agreed the problem be referred to the Young Engineering Teachers Committee for consideration. The discussion indicated the general belief that all YET activities should tend to pull men into the Society, that non-ASEE members could attend meetings of YET, but membership in a YET organization should require ASEE membership.

15. *Section Meeting Papers—Property of ASEE*

Vice President B. R. Teare, Jr. presented the problem and it was agreed Article 9, Section III of the Constitution should be referred to the Constitution and By-Laws Committee with the recommendation that, "shall be the property of the Society," be deleted.

16. *Committee Appointments*

a. EJC Committee on Honors for Engineers—The committee is to develop methods by which distinguished engineers may receive suitable recognition . . . and consider the establishment of awards by EJC. W. N. Jones represents ASEE.

b. U. S. National Commission for UNESCO—It was agreed the President should make appointments provided there would be no cost to the Society.

c. National Research Council—Vice President H. K. Work presented the difficulty arising from the fact that the ECRC Vice President serves for two years and the NRC appointments are for three years. It was agreed the policy should be that the ECRC Vice President be the ASEE representative to NRC and that at the end of his two year term as vice president he resign as the NRC representative.

d. Incorporation of nuclear science into engineering curricula (added to agenda) —The Secretary read the letter dated March 31, 1955 from Dean R. D. Hawkins, chairman of the Atomic Energy Education Committee. It was agreed the committee itself should make recommendations and the Secretary is to pursue the matter with Dean Hawkins.

17. *Applications for Affiliate Institutional Membership*

a, b, c. None of the three applicants had a curricula approved by ECPD but the Executive Board voted to approve membership if equivalent accreditation could be established.

It was agreed that if an institution was not eligible for membership its top officer

should be invited to join ASEE in order for the institution to receive the benefits of such membership.

17A. *Associate Institutional Memberships* (added to agenda)

The Secretary announced that by mail ballot the Executive Board *voted* to approve membership for:

American Blue Print Co., Inc.
Udylite Corporation
Continental Motors Corporation, Research Division

18. *EJC Amendments and Membership*

a, b. It was agreed to refer the application of the American Society of Refrigeration Engineers as a Constituent Society and of the American Institute of Industrial Engineers as an EJC Associate to the General Council for approval.

19. *ECPD Membership for NSPE*

It was agreed to refer the matter to the General Council for vote.

20. *Tax Exempt Status of ASEE*

It was agreed to refer the problem to the auditor, if necessary, for study and recommendation.

21. *American Council on Education Dues*

The Executive Board *voted* to pay the $200 dues for the current year.

22. *Educational Advice and Aid to Foreigners, IAESTE*

It was agreed to refer the correspondence to the International Relations Committee for appropriate study and recommendations.

23. *Dean's Conference at Cornell University*

The conference was discussed briefly without taking any action.

24. *Other Business*

a. The Secretary read the announcement of the death of Mrs. Florence Hooven.

b. The next meeting of the Executive Board will be at The Pennsylvania State University, Monday morning June 20, the exact time and place to be announced later.

c. There being no further business the meeting adjourned at 6:40 P.M.

Respectfully submitted,
W. LEIGHTON COLLINS
Secretary

ANNUAL MEETING

June 20-24, 1955

Pennsylvania State University

UNIVERSITY PARK, PENNA.

(formerly State College)

The Humanistic-Social Studies in the Engineering Curricula*

By DR. EDWIN S. BURDELL

President of The Cooper Union

To this title, "The Humanistic-Social Studies in the Engineering Curricula," might well be added the prefix, "the problems of establishing and maintaining," for after all the definition and values of the humanistic-social stem have been stated elsewhere by many leaders in engineering education. I shall undertake to discuss this subject from four points of view: integration versus articulation, problems peculiar to the independent engineering college and to the university engineering college, how to find the time for inclusion of the humanities in a professional curriculum, and, finally, tailor-made versus ready-made humanistic-social programs.

Generally speaking, there are two ways by which the humanistic-social studies can be related to scientific-technological studies. One way provides an articulated relationship; the other, an integrated relationship. An example of the method of articulation is a plan whereby, following the pattern of preparation for medicine and law, a one- or two-year liberal arts program can be required as a prerequisite for professional education. The arguments in favor of this arrangement, so I have heard, are that the young college student can catch more culture by being completely immersed in it, that the sequences of liberal arts and professional training are more meaningful because each is concentrated in a smaller time-capsule. I disagree with this theory because, in the first place, it places a road block of subject matter between the eager high school student and his chief interest, science and its applications, causing him perhaps a life-long emotional distaste for having anything more to do with the humanities. Furthermore, it gives him the notion that, having "passed off" those requirements, he can forget the field and devote himself exclusively to technical specialization. I doubt that there will be much carry-over to the young engineer's professional beginnings from this too early and too concentrated humanistic exposure. In fact, I am inclined to refer to articulation somewhat unkindly as a preheat treatment, which casehardens the embryo engineer against the very interests, attitudes, and philosophies that the liberal studies aim to awaken and stimulate.

Another approach to articulation is by an arrangement whereby the junior year liberal arts student transfers to an independent engineering college for his fourth and fifth years. He usually receives a bachelor of arts degree and his engineering degree at the same time. This is a plausible way of having your cake and eating it too—if it works! But it robs the liberal arts student of his senior year, the final crowning year of his undergraduate experience. It denies him the satisfactions of completion of his curricular and extracurricular program, and cuts off abruptly the associations built up on the campus, which in a small liberal arts college are usually very warm and intimate. It pitchforks him on to another campus where he is a stranger and where in two

* Presented at the semi-annual meeting of the Mid-Atlantic Section, ASEE, Polytechnic Institute of Brooklyn, Dec. 4, 1954.

years he can scarcely hope to make a place for himself in the undergraduate scheme of things. This arrangement exists between many liberal arts colleges and some of the leading engineering schools. It bears watching and for a certain type of student to whom undergraduate life is relatively meaningless, of course, the loss of the values that I have just mentioned is no real loss at all.

Now, turning to integration, I would like to point out that this method of introducing the humanistic-social studies offers continuity and flexibility. By this method a four-year vertical sequence of one three-hour-a-week course each semester can amount almost to the equivalent of one full year of liberal studies in the engineering school. Pedagogically, an uninterrupted contact with the liberal studies during the pursuit of a science and engineering course does much to exemplify the wholeness of knowledge and should go far to dispel the false notion of a dichotomy between general and technical education. This arrangement also facilitates a correlation among the forces at work in society at a given time; for example, between the intellectual ferment and the social upheavals of the eighteenth century. It can provide understanding of the impact of the prevailing mores on the inquiring mind throughout the history of western civilization. Teachers of the physical sciences and social science teachers can join forces in bringing to life the relationship between science and society so that the student will be in a position to develop his own personal philosophy of life along with a real understanding of the goals and responsibilities of his chosen profession.

Such integration provides for building one course upon its predecessor, offering more difficult and profound subject matter in the upper years, thus avoiding superficiality and lack of depth. It may, under a scheme that we prefer at The Cooper Union, provide for matching the highly particularized professional engineering studies in the senior year with generalized philosophical concepts, while, in the early years, the basic generalizations of physics, chemistry, and mathematics are matched by particularized disciplines of English composition, speech, and so on. Finally, it provides to humanities teachers the opportunity to obtain the satisfaction of offering more advanced material at higher standards than would be possible if they had to confine their efforts and interests to the immature first- and second-year students.

Two Frames of Reference

My second point for discussion is the problem of teaching the humanistic-social studies within the two frames of reference —the independent engineering school and the university engineering school. The great advantage in the independent engineering school is that the humanistic-social faculty members are an integral part of the science and engineering faculty. They share the common objectives of engineering education with their colleagues. Subject matter fields are apt to have fewer rivalries if all of the humanistic-social studies are taught by men in a single humanities department. Communication among the science, engineering, and humanities teachers is apt to be good and the humanities teachers themselves are apt to be more enthusiastic about their jobs because they have an undivided loyalty to a common objective.

Now, of course, there are disadvantages. The smaller independent engineering colleges may not be able to afford the diversity of teachers desirable for a broad offering of subject matter. Hiring of part-time teachers defeats the unity that I mentioned above. Then there is a tendency to dispense with the "frills" and set up courses with such misleading titles as "Engineering English," "Engineering Economics," and so on. From the standpoint of the ambitious specialist in the humanities and social sciences, there appears to be little or no opportunity for research and graduate teaching and the

job looks like a dead end with little or no job satisfaction or professional prestige.

The advantages to the humanistic-social stem in the university engineering college lie in the wealth of talent that the university offers. These cultural resources could be of tremendous value in enriching a sequence in the liberal arts and social sciences. However, the danger of not making the most of these riches is exceeded only by the difficulty of achieving a satisfactory allocation of teachers and classes. For instance, liberal arts teachers assigned to teach engineering students are likely to be young graduate students primarily interested in pursuing advanced work in their own fields of specialization. They are not apt to be invited to participate in curricular planning; hence, they cannot share the enthusiasm or appreciate the objectives of engineering education. The dean of engineering with the best of intentions may allot, if his faculty permits, a certain number of credits in the humanistic-social stem in the hope that the engineering students, innocent of intellectual dietetics, will choose with discrimination from an educational smorgasbord. Of course, there are exceptions; and one of the best situations I know of was that which existed at The Ohio State University while Miss Sada Harbarger, of the English Department of the Arts College, was teaching English and literature to the engineering students. Miss Harbarger, on her own initiative, did undertake to find out what the engineering faculty wanted to accomplish and went ahead and constructed and taught the courses.

When engineering students do not have their own sections in the humanistic-social studies and are compelled to take those studies with liberal arts students, they find two significant difficulties. First of all, the liberal arts students presumably are going on for advanced work; hence neither the instructor nor the members of the class finds any common interest with the engineering student who is limited to one or two courses in any humanistic subject matter field. Secondly, elementary teaching in the liberal arts college of a large university is apt to be in large lecture and quiz sections affording little opportunity for discussion and individual attention, whereas the engineering student is accustomed to small classes and close association with his science and engineering teachers.

My third topic is how to find the time. It has been recommended that the humanistic-social stem should include history, economics, and government, wherein knowledge is essential to competence as a citizen, and literature, philosophy, psychology, and fine arts, to broaden the engineer's intellectual outlook. This is a large order and we all know the curricular jug is full. Hence, my advice is to do a more efficient job of teaching of the scientific-technological studies, minimize the descriptive material and the repetitive drill, and encourage solving a few problems on the basis of science principles rather than emphasizing a large number of problems. Perhaps an honest re-appraisal of the scientific-technological curricula would lead to fewer courses in all and also fewer courses given simultaneously. Engineering faculties will have to get accustomed to postponing more and more technology to the graduate years. Indeed they might well reduce specialization in the undergraduate program by experimenting with a single engineering curriculum leading to a bachelor of science in engineering. The American Society for Engineering Education and the Engineers' Council for Professional Development have suggested in the last six months that more thought be taken of ways to simplify and intensify engineering education.

Fundamental Re-grouping

In my opinion, the answer does not lie in the five-year undergraduate program. The evidence is not convincing that under this lengthened plan the pace is slower or the amount of humanistic-social subject

matter is greater. Not lengthening but shortening is what I would propose for professional education, and that by a fundamental re-grouping of our American educational system.

Specifically, I propose that grades 7, 8, 9, and 10 be combined into what, for want of a better title, I would call a Middle School. Grades 11 and 12 would be brought up to the European standard of the lycée or gymnasium—terminal for most students, but preparatory for those others who have demonstrated their intellectual capacity for university and professional training. It is hard-headed realism, not intellectual snobbery, to say that our American educational system cannot afford the extravagance of offering higher education to a vast number of unqualified youth. On the other hand, our dynamic society requires urgently that those intellectually qualified but economically handicapped be given the opportunity to train for professions. I have said elsewhere that there is no place in higher education for the mediocre student. Annual tuition in the private college costs up to nine hundred or a thousand dollars and campus living up to another eleven or twelve hundred dollars. Yet this huge expense represents only a part of the total cost of education that must be made up out of endowment income or alumni giving. In this situation, the American parent and the American educator have to come down to earth and provide for those students most able to benefit by the intellectual training. When the increase of college-age population hits the colleges with its full impact, they will be forced to decide between selecting qualified students or expanding to accommodate without discrimination all those who apply.

On another level of education the subprofessional technical institutes must be greatly expanded in number to prepare men and women for the supervisory functions—ever more demanding in an era of automation. Adult education, both avocational and vocational, will be needed as leisure time increases and as jobs change with a rapidly changing technology. For those who cannot afford post-high school education away from home and who are not destined for professional or sub-professional careers, the junior college will fill a great need. Unfortunately, the connotation of "junior" is belittling and should be modified. If some form of universal military training is superimposed on our present system of education, the need will become all the more acute for compressing and shortening the period of preparation for professional practice.

Whether or not my proposals for overall educational reorganization are accepted, whether professional education comes earlier or later in the student's life, whether it is more or less selective, we all, I think, are agreed on the importance of a program of humanistic-social studies in engineering education. But what program? Shall it be tailor-made or ready-made? In the effort to live up to and implement the recommendations of the famous 1940 and 1944 reports of the Society for the Promotion of Engineering Education, some deans of engineering were inclined to apply a formula instead of deriving enriched curricula out of the resources of their own institutions. No educational program can be thus produced ready-made with mechanical uniformity. Teachers, library, budget, and the relations of the engineering school to the university all are factors that need to be taken into consideration in setting up each individual sequence of humanistic-social studies. The 1944 "Report of the Committee on Engineering Education After the War" recommended an allotment of time equivalent to one three-hour course extending throughout the curriculum, and on the average somewhat more. But caution should be exercised to limit subjects to those that can be staffed adequately and taught enthusiastically. A few well-taught subjects are much to be preferred to a smattering of poorly taught courses.

The Committee referred to above said under the topic of "Program and Method of Instruction": "While the selection of subject matter suitable to the achievement of the aims of humanistic-social studies is important, we believe that this will present less difficulty than will devising appropriate methods of instruction. . . .

"The knowledge of miscellaneous details of the subject matter selected is less important for engineering students than is the acquirement of the ability to understand, to analyze, and to express the essentials of an economic, social, or humanistic situation or problem, and to appreciate the implications and relationships of such problems to the life and work of an engineer.

"Formal expository methods are often used in these fields. We believe they are less effective in accomplishing the results advocated than a method which places responsibility on the student himself. Such a method should require him to read, to question, to seek evidence, to weigh, to judge, to accept, and to express the results of his efforts in written or oral form both in school and in life situations."

And now I would like to comment briefly on a few topics related to the four I have discussed. The impact of advanced Reserved Officers Training Corps is definitely hampering to the upperclass student who has devoted all his twelve elective credits to military subjects to the exclusion of humanistic-social electives and even some science electives. The dean of an engineering college in a university can do little about this detrimental substitution because policy is determined at a higher level, but I understand that in some independent engineering colleges advanced R.O.T.C. is regarded as a paid extracurricular activity for which no academic credit is given.

Another way in which engineering colleges might cope with the shortage of time available for humanistic-social studies is to make more of the learning possibilities inherent in well-administered student activities, such as publications, debating, dramatics, student government, and so on. There is no reason why these extracurricular activities should not enjoy status and prestige equal to those of the student branch chapters of the various engineering societies. Again referring to the Committee on Engineering Education, its report recommended, under "Methods of Organization": "Encourage engineering students to participate in expressional activities (music, dramatics, public speaking, painting, etc.); and in student organizations concerned with public and social problems; provide organized opportunities for attending the theatre, concerts, art exhibits, etc., and assign themes and reviews based on these events."

Conclusion

Finally, let me conclude with the observation that too few of our students ask the meaning of what they are doing, or speculate about the significance of their vocations in the total framework of human life. Until too late, they fail to see that the difference between vocational training and professional education lies not so much in the subject matter studied but rather in the spirit in which it is approached—the breadth of view, the kinds of questions raised, and the value judgments taken. The humanistic-social stem will never succeed in reaching its objectives of providing the student with the basis of a sound personal philosophy unless the student is convinced that the pursuit of such studies is valuable and significant. Motivation for such studies can be found by the student in the enthusiasm of the instructor of mathematics perhaps even more than in the exhortation of the English teacher. The faculty, all of its members, must share a deep enthusiasm for a deep and broad approach.

It is well to consider as we have here the problems of humanistic-social studies in the undergraduate engineering curricula. But we must not lose sight of their

ultimate goal, the training of future leaders, not only conscious of three thousand years of cultural heritage, but also alive to their responsibilities to American society in the second half of the twentieth century. In dedicating ourselves to turning out specialists in science and technology, let us not forget that the last word in policy decisions will be made by the generalist, one whose education and experience in law, engineering, or business have taught him to equate legal, physical, economic, and human values. Aren't we aiming to equip most of our graduates ultimately to be able to serve among those generalists?

College Notes

The **Duke University** College of Engineering has established a new program to combine liberal arts and engineering studies. Duke will cooperate with selected liberal arts colleges throughout the United States in the "three-two program," which will get underway this Fall. The program will be operated along with the University's regular four-year engineering curriculum. Only a limited number of outstanding students will be admitted.

Each participant will attend a liberal arts college for three years and then the College of Engineering for two years. After a total of five years, the liberal arts college will award a Bachelor of Arts or Bachelor of Science degree, and Duke will award a Bachelor of Science degree in engineering.

The **Illinois Institute of Technology** Alumni Association presented a distinguished service award to Arthur B. Bronwell, president of Worcester Polytechnic Institute and former ASEE Secretary on May 6.

Plans for two Special Summer Programs on "Strain Gage Techniques" to be given at the **Massachusetts Institute of Technology** during the 1955 Summer Session, have been announced. "Fundamentals of Strain Gage Techniques" will be given from July 25 through July 29, and "Applications of Strain Gage Techniques" from August 1 through August 5. Full details and application blanks may be obtained from the Summer Session Office, Room 7–103, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

The Glenn L. Martin Institute of the **University of Maryland** was dedicated recently. Erected at a cost of $8.5 million, the institute is made up of eight buildings which house the entire College of Engineering and many of the academic and research departments of the College of Arts and Sciences.

The Complimentary Role of Physics and Mechanics in Engineering Education

By GLENN MURPHY

Conference Secretary, Professor and Head of Aeronautical Engineering, Iowa State College

Among the many ideas being explored in the continual attempt to improve engineering education is that of eliminating unnecessary duplication of effort in allied departments. At the outset, it is evident that some duplication of subject matter, particularly as it relates to principles, is essential. However, undue duplication robs the student of the opportunity to receive instruction in additional areas which may be vital to his continued growth and development throughout his professional career.

One possible area of duplication is that of mechanics as it is usually taught in the department of physics and later in one or more departments in engineering. To explore the teaching of mechanics, the National Science Foundation sponsored a conference of about twenty of the leading educators in the field. The conference was organized by the Physics Division and the Mechanics Division of the American Society for Engineering Education under the guidance of Prof. F. L. Singer of the Engineering Mechanics Department of New York University, who is also current chairman of the Mechanics Division of ASEE. The conference was held at the Gould House of N. Y. U., 23–26 January 1955.

In evaluating the instruction in mechanics as it has been and is given by physics departments, the group found that in the majority of schools the courses in physics are considered prerequisite to engineering mechanics. As a result the student is exposed to a barrage of ideas, concepts, principles, formulas and solutions to problems at a rate well above that at which he can be expected to absorb them simply because so much material must be covered in so little time. The students quickly learn that grades are assigned on the basis of problems solved in examinations and problems are solved by formulas. Consequently, they place the emphasis on formulas and seldom attain the depth of understanding of principles that is desirable and increasingly essential. This is particularly true when the instruction is in the hands of graduate assistants.

As the conference progressed it became clear that the function of the first course in physics in an engineering curriculum should not be that of serving as a prerequisite to mechanics and other engineering courses. Instead, the course should be directed toward giving the student an understanding of the concepts and principles that are basic in our physical world. Applications of the principles in the physics department should not be directed toward the solution of those engineering problems that must be considered later in detail in engineering mechanics. Rather, the applications should be directed in such a way that the student will develop confidence in his reasoning ability, and his ability to arrive at correct conclusions when working with phenomena the details of which are not directly apparent.

In the physics course the emphasis should be on synthesis, or the building up of an understanding of laws and principles governing physical phenomena. On the other hand, the primary objective of the courses in mechanics in engineering

is that of predicting the behavior of real engineering systems. Consequently, the emphasis in engineering mechanics will necessarily be on analysis and problem solving rather than synthesis and principle development.

With these objectives the initial course in physics for engineers will not be subordinated to engineering mechanics in functioning as a prerequisite. The training in mechanics in physics departments and in engineering was visualized by the members of the conference as proceeding most advantageously in parallel, rather than in sequence, with numerous cross ties to lend mutual support, strengthening and balance. In this way the first course in physics may be better designed to serve as a base for later courses in atomic physics or nuclear physics for which increasing demand is expected to develop. With the broader scope of engineering physics as visualized by the conference, it is clearly evident that the instruction in the first course in physics for engineers must be in the hands of the most capable teachers who will give it sympathetic and dynamic treatment, and that it not be relegated as a chore for graduate assistants.

In considering solid state physics as a part of the physics program, it was brought out that the engineers are interested in a course at the junior or senior level that will give the students some insight of the behavior of materials so that the development of courses in engineering materials can proceed along other than strictly empirical lines. It was conceded that classical solid state physics is at the graduate level for physics majors.

Instruction in mathematics as it related to the problem was considered and led to the conclusion that the student should be introduced to the concepts and a working knowledge of calculus as early as practicable in his college curriculum. It is equally important that the mathematics then be used in the engineering courses.

The discussions culminated in the following statement which was adopted unanimously by the members of the conference.

"The conference found, after a careful analysis of the statements of the objectives of undergraduate instruction in both physics and engineering, that the objectives are not competitive in scope but actually complementary when the courses are properly planned and taught. It cannot be over-emphasized that the instruction by physicists will provide the engineering student with an understanding of physical phenomena basic to much of his later studies. On the other hand, the objective of instruction in mechanics by engineers is to achieve professional competence in the practical solution of problems encountered in engineering.

"We conclude, therefore, that there is an essential difference in the approaches to mechanics by the physicist and the engineer. There is a place and, indeed, a need for both of these approaches to the teaching of mechanics. The different objectives should continually be recognized and used as guides in planning courses.

Objectives of Physics Instruction in Mechanics

"The primary objective of physics instruction in an engineering or scientific curriculum is to provide the student with an understanding of the physical principles that describe nature, of how these principles have evolved, and of their scope and limitations. Such an undertaking must begin with the study of Newtonian mechanics. Great emphasis should be placed on the conservation principles. The generalization of these principles along with associated concepts has formed the basis for modern physics, including such special branches as atomic and nuclear physics and the physics of the solid state. With this approach, it is neither practical nor desirable in the physics course to devote attention to the development of facility in detailed application of physical laws to practical problems encountered in engineering practice. Stimulating problems should be

selected with a view to illustrating physical principles, and it is essential that they be accompanied by a challenging laboratory experience. These courses, approached in this manner, should provide an adequate base for the student's continued scientific growth.

"In order that the study of Newtonian mechanics be effective in setting the stage for a proper understanding of the concepts and methods of modern physics, it must be recognized that a significant difference exists between the older physics and most of modern physics. In modern physics a large amount of theory is often interposed between observations and the conclusions based on them. Nevertheless, the pedagogical approach in which macroscopic observations are used directly as a guide in building theory must first be employed, as it can in mechanics; the student must later be led to the present day methods of inferring conclusions regarding phenomena not directly observable. These methods are in fact used in kinetic theory, optics, and electricity, as well as in many topics of modern physics.

"To achieve this goal, the role of conservation laws in mechanics and electricity can hardly be over-emphasized. The study of mechanics should also include the dynamics of systems of particles, wave propagation, standing wave systems, etc. Valuable for later work in modern physics will be the study of resonant systems, such as the mechanical harmonic oscillator, accompanied by demonstrations or discussions of similar resonant systems in electricity, nuclear-magnetic resonance, and examples from acoustics and optics. It is in this spirit that instruction in mechanics makes a significant contribution toward the understanding of phenomena in atomic, nuclear and solid state physics.

Objectives of Instruction in Mechanics by the Engineer

"The prime objective of instruction in engineering mechanics is to provide the student with a useful understanding of the methods and principles needed to design and predict the performance of real engineering systems and structures. The preparation of engineers for creative design should be kept always in mind. Creative design requires as much ingenuity, imagination, and resourcefulness in the application of physical laws and principles and in making them useful to man as is required in the original formulation of them.

"In order to solve real problems of the great variety and number that are presented to the engineer, it is necessary that he become proficient in a systematic method of problem solution. Consequently, instruction in methodology is an essential part of engineering mechanics. Instruction must include ample emphasis on the following operations which are basic to engineering analysis.

"The student must learn to identify the essential elements and characteristics of each specific engineering problem. Is it, for example, one involving statics or dynamics, rigid or deformable bodies, a conservative, or a dissipative system? He must be able to select relevant information and data and recognize those which are not pertinent. In doing this an ideal model must be created and the problem made amenable to solution. The results based on the idealized model must next be interpreted in the light of the original real situation. The engineer must form a judgment of the extent to which he can rely on the results obtained on the ideal model, and finally he must be able to communicate this to others in suitable and usable form.

"The engineer must devote major emphasis to the formulation and evaluation of his problem quite apart from the necessary analysis. Instruction given the engineering student should reflect this fact.

"It is in this spirit that the instruction in engineering mechanics assumes a significant role as a springboard to a truly professional attitude and approach to all engineering situations.

Objectives of Instruction in Solid State Physics

"Before considering the place, if any, of solid state and nuclear physics in engineering curricula, it is desirable to consider the activities of physicists in these respective fields. In nuclear physics, the physicist is concerned with the quantitative behavior and structure of nuclei, the nature of forces involved between nuclear particles, and the interaction between nuclei and radiation. In solid state physics the physicist in seeking to develop an understanding of the properties of solids on the basis of their atomic constitution.

"To take part in the current activities in either of these fields requires a background and a working knowledge of quantum mechanics as well as of the general principles and conservation laws of classical mechanics and electrodynamics. Such knowledge can be obtained only through several years of study, generally including graduate work. This conference is convinced that there is no shortcut by which this knowledge can be given to undergraduate engineering students by means of a one or two-semester course in modern physics.

"On the other hand, an introductory course of one or two semesters' duration covering some of the topics mentioned above could be given following the general physics course. Such a course should broaden the training of the undergraduate engineer.

"It is the conviction of this conference that the time should not be taken from that now devoted to an understanding of the fundamental principles of mechanics, which should be required of all engineers. Instead, the conference recommends that the basic physics course be strengthened by greater emphasis on fundamental classical principles and conservation laws, and by an introduction to wave and quantum concepts. Inclusion of these topics is an essential introduction to the later study of solid state or nuclear physics. It is also recommended that as far as possible, such particles as electrons, protons and neutrons be used in the elementary physics course to illustrate general dynamical principles. In the case of existing two-year physics courses, it is the belief of the conference that some concepts of modern physics can be introduced without requiring additional time. In the use of one-year physics courses, an extension of time of at least a semester is recommended.

Mathematics Instruction as Related to Mechanics

"It is urged that the concepts of calculus be introduced in engineering curricula as soon as possible, preferably in the freshman year, and used in physics and engineering as soon as feasible.

Conclusion

"In comparing the different objectives and points of view of instruction in mechanics by physicists and engineers, it should be emphasized that the physicist uses problems and examples from experimental physics essentially for the purpose of developing by the inductive method those concepts and principles which it is his objective to have the student understand. The engineer, on the other hand, uses certain concepts and principles for the purpose of achieving the solution of practical engineering problems. This distinction should determine in a major way the essentially different character of illustrative material used in each area.

"If instruction in physics and engineering mechanics follows the objectives outlined, it appears that, although some duplication of content is inevitable and even desirable, the real duplication in terms of influence on the engineering student will be negligible. On the other hand, if instruction in physics follows in any major way the direction of application to engineering situations, or if instruction in engineering mechanics fails to emphasize the professional engineering approach, then this duplication will result in a serious waste of time.

"Consequently, it is evident that the preservation of the two different but mutually supporting points of view of the physicist and the engineer is a necessary condition for maintaining the progressive program of engineering education, which in these critical days is of vital interest to the entire nation.

"Finally, the conference recognizes that progress occurs through continuing experimentation, and therefore recommends that such an attitude be encouraged in the teaching and the curricular arrangements of physics and engineering mechanics."

Throughout the conference there was the recurrent theme that the improvement of engineering education, which is of vital concern to all, can be achieved through the enthusiastic participation of individual staff members in coordinated local programs of evaluation and improvement of teaching of engineers. While a conference of the type held at the Gould House can indicate general patterns of improvement, the details which constitute the real benefits must be worked out at each school in harmony with the particular local situation. It is only through continual experimentation toward improvement at the individual institutions that over-all progress will be made.

A detailed report on the conference is the subject of one session at the annual ASEE meeting at Pennsylvania State University in June.

The participants in the conference were:

Dean J. W. Buchta, University of Minnesota
Prof. J. W. Cell, North Carolina State College
Prof. P. F. Chenea, Purdue University
Prof. W. L. Collins, University of Illinois
Prof. J. P. Den Hartog, Massachusetts Institute of Technology
Dean H. Fletcher, Brigham Young University
Prof. N. Frank, Massachusetts Institute of Technology
Dean L. E. Grinter, University of Florida
Dr. G. H. Hickox, National Science Foundation
Dean E. Hutchisson, Case Institute of Technology
Dean R. B. Lindsay, Brown University
Prof. J. L. Meriam, University of California
Prof. Glenn Murphy, Iowa State College
Prof. M. S. Plesset, California Institute of Technology
Prof. J. J. Potter, Texas A and M
Prof. J. A. Sauer, Pennsylvania State University
Dr. Raymond Seeger, National Science Foundation
Prof. F. L. Singer, New York University
Prof. I. S. Sokolnikoff, University of Calif. at Los Angeles
Prof. W. B. Stiles, University of Alabama
Prof. D. Williams, Ohio State

Towards Improving Student Teacher Relationships

By F. D. EZEKIEL

Instructor in Mechanical Engineering, Massachusetts Institute of Technology

During the 1954 Spring Term a group of instructors and professors in the Mechanical Engineering Department got together for one hour a week with Dr. Harris, Psychiatrist of the Massachusetts Institute of Technology, to study and analyze the whole mechanism of teaching. The following represent some of the ideas that came to light during those meetings, plus some of my own personal experiences and findings.

During the very first meeting we uncovered the most important point. Before trying to improve our teaching methods and learn all about the students, Dr. Harris pointed out that it is of the utmost importance to look first of all into our own motivations in teaching. In other words, we have to study ourselves first. We have to ask ourselves the following questions: Why am I a teacher? Do I like teaching? What are my attitudes towards teaching, students, courses, etc.? What personal satisfaction or reward do I get out of teaching? What type of personality do I have? What are my weaknesses? Do I derive pleasure in imparting knowledge to others, flunking students, showing others how much I know, or acting as a supreme authority? Do I try to make my students happy? Do I arouse their enthusiasm, curiosity, and interest? Do I consider the students' feelings? Do I have the patience, tolerance and perseverance to deal with students? Am I teaching because I like to teach, because it is an easy profession, or because I am afraid to go out and seek another job?

The answers to these questions and many others help us to understand and possibly to solve some of the important problems involved in teaching. It is amazing how frequently we tend to blame the student for certain faults when we are really the ones at fault, because the student is only responding in his own way to what we have to offer.

After having acquired a clear and deep understanding of ourselves and our motivations, the next step is to learn as much as possible about the students. Here again it is imperative to ask ourselves some more questions: Who is the so-called student and what are his motivations? Is he here because he has the inward desire to learn, or is he here because his parents want him to study, or because going to college is the thing to do? Does he enjoy studying? How mature and responsible a person is he? Is every course to him another package of learning or another hurdle before his degree? Is he intelligent and capable enough to handle what we are offering him? What does he think of the teacher? How does he respond to him? Does he picture him as a person who is interested in helping him or another authoritarian like his father or uncle who has bossed him? Does he like or resent authority? Does he think the teacher to be honest and desirous of helping him pass the course, or tricky and seeking to fail him? How does he regard quizzes and grades? etc.

After having learned as much as possible about the student, the third step will naturally be to study the interaction between teacher and student. Inasmuch as people are basically different in many respects, it is rather difficult to set specific yet universal patterns of behavior that fit all instances. The best solution is to

study each case separately. However, since students in general do have a lot in common, there exist many similar types of interactions, and correspondingly similar successful methods of action on the teacher's part. The following are some of the points I found that help make teaching more effective.

Aside from the classroom teaching abilities and techniques, the most important element that determines the teacher's success and popularity is the type of relationships that he can establish between himself and his students. Students in general are extremely sensitive and therefore are more easily apt to form opinions about teachers that are very hard to change. It is during the very first few class periods that most of the attitudes are established.

Here Mr. Teacher walks in for the first time to tell his students how he proposes to run the course, how much quizzes and homework count, what he expects the student to do, and how he penalizes and punishes. Mr. Authority himself! The student reacts to this in various ways. He may take up the attitude of wait and see, or he may feel this is another authority in his life like his older brother, for example, and will immediately then transfer all his attitudes, defense mechanisms, and resentments, which he had developed earlier, to his new teacher. He may like him, hate him, or be completely indifferent. These initial opinions may change depending on how the teacher answers his questions in class, helps him in his homework difficulties, or even grades his quizzes. Accordingly, the student's class attendance, enthusiasm to study and successfulness on quizzes are at least partially dependent on how he feels towards the teacher.

Thus, the student-teacher personal relationship is extremely important for successful teaching. As a consequence, the teacher always must be careful when dealing with students. He must strive to keep his students happy and make them like him as much as possible, especially the students whose grades fall on the lower half of the scale. A student's pride can be injured very easily and unintentionally. For example, when a student asks a relatively simple question to which he is supposed to know the answer, the teacher may easily hurt the student's feelings by consciously or unconsciously ridiculing him. In most cases, it will be the last time that particular student will ask that teacher a question. As a result, he will resent the teacher and let other problems ride and, as a consequence, may fail the course.

To cite another example, when a student having felt cheated on his quiz grade, comes to see his teacher, the latter may spend a long time telling the student how carefully he graded all the other quizzes and how unfair it would be to change any grade. What will the student's reaction be? He is likely to think the teacher to be a block of concrete, tough and unyielding. He most likely will refrain from coming to see the teacher, not only with future problems with quiz grades, but also for any other problem. This has happened all too frequently—the student's personal relationship with his teacher is shattered. On the other hand, assume that the teacher takes an "easy-going" attitude. He gives the student the impression that he is ready to change his grade if a good argument can be presented, that he is thereby willing to give him the benefit of the doubt. What will happen? The student walks away happy with a sense that his teacher is an understanding man after all: if he manages to get an increase in the grade he will feel satisfied; if not, he at least gets the assurance that his teacher is a reasonable person to deal with. It is my own personal finding that, for the most part, this student will then spend more time in course preparation, and will as a result improve on the next quiz. In this way one can win the student's friendship and avoid being known as a "tough grader" or "slave driver."

Since a good student-teacher relationship is very much desired, the fourth step explores means of achieving it: by what

methods or schemes can you make friends with the sullen student, the one that thinks you are tough and tricky, the one who pictures you as a cruel authoritarian or the silent one who does not dare talk to you? The solution is simple. Make a definite appointment with the student to come to see you in your office. Once together, start asking him some simple questions in order to encourage him to talk to you. Be kind and gentle with him and above all, a good listener. The student, given his chance, will talk. Let him speak about anything. By so doing, the barrier that so often keeps people apart melts away. The student at ease will begin to think, "I have found a friend."

The importance of these words cannot be underestimated. This student will like and respect you. He will attend your classes and will study hard what you assign to him. In some cases he will even develop a great liking for your course and make it his field of specialization. You have inspired him and have become his friend. For example, a certain student I know failed his first term quiz and came to see me at my request. He told me all about himself, his family, and how his father sells lawn mowers. For fifteen minutes we talked thus. The quiz he failed was mentioned only in passing. We talked as friend to friend. On the next quiz he earned one of the highest grades and wound up the term with an "A" for the course. He wrote on his instructor evaluation sheet: "As a further indication of my pleasure with the teaching techniques, I have even attended many Friday classes despite the fact that I am home the preceding hour and have no classes following."

Another student who could be classified as sullen came to see me after obtaining the lowest grades on the two previous quizzes. It is not difficult to imagine why this student was not friendly. I gave him a chance to talk using every method I knew. After ten minutes he broke down and smiled, "Sir," he said, "I've got a block against you. I thought you were very tricky in that first quiz. When I took the second quiz, I was so nervous that I couldn't do anything. . . ." I then very briefly explained to him what my objective was in quizzing him and that I understood how he felt. By merely talking over his complaint, this student has discovered for himself my true attitude and hence has erased the conflict to save himself from a dangerous situation. From that day on, not only his class attendance and homework improved, but he obtained a relatively high grade on the next quiz and eventually passed the course. It is true this procedure is time-consuming especially on the teacher's part, but the results are unquestionably very worthwhile.

As regards effective classroom teaching techniques, it is very hard to outline any special ones since these are highly personal and dependent upon the personality of the individual teacher. However, I have found that enthusiasm on the teacher's part is of paramount importance. Creating an atmosphere of friendliness and warmth, establishing a relationship of confidence and fearlessness, having respect for the students, avoiding serious criticisms, offering challenges, keeping the class awake and attentive by asking suggestive, thought-provoking questions, and calling on students to take active part are effective tools. Generally, students tend to assume a highly passive mood during lectures and find it hard to change when exams come around. Encourage questions and discussions and respect everything that students ask. There are hundreds of students who don't dare ask questions to solve their difficulties for the simple reason that they are afraid to let the teacher and the other members of the class know how much they don't know. This is a great pity and can be solved. It largely depends on the teacher's attitude and motivations.

In conclusion, it seems to me that teaching methods can be improved and it is entirely up to the teachers to do it. If students fail, it is not wholly their fault. Many an unhappy situation can be avoided if the proper action is taken at the right time.

• • • YET-ITUDES

• *yelps and helps for the young engineering teacher*

Contributed by CYET
PHIL WEINBERG, *Chairman*
University of Utah

LEE HARRISBERGER
Editor of YET-itudes
N. C. State College

"The Uneagered Beaver"

At the beginning of his career in teaching every YET has to some degree an ambition to do a better, more unique job of teaching engineering. This is only natural because there is no one who has more faith in himself than the man who hasn't tested his power. This is motivator No. 1. The second big motivating force is inexperience. The YET wants to jump in feet first and try something because he is too "green" to know it can't be done. Consequently, he experiments with his teaching. He tries many things that have been tried by others, makes mistakes, goes up blind alleys, and finds out that some of the things the old timers have told him are true. But, he's trying.

If there were no experimenting, no one would know what would work and what wouldn't. Experience is knowledge gained from "trying it out." Progress is making mistakes.

But, there aren't enoughs YETs making mistakes. The natural inclination of the YET to "mix-it-up" in his work is too often squelched too soon in his career. The JOURNAL is full of theory articles but it doesn't often get to report the results of a brave soul's attempt at trying out the theory. There is little encouragement to strive for better methods. It is too easy for the YET to degenerate to a level of unconcerned complaceny—to become a victim of habitual doing. Even the more determined "eager beavers" find pioneering to be a futile task and give it up.

We looked around to see what were some of the things that "stall out" the eager YET. Furinstanz:

- There seems to be quite a bit of pressure from the old timers to have the course taught their way—using the text they have adopted.
- The YET is all too often given too large a teaching load. In any case he has too much teaching to do for a beginner. There is so much routine he can't possibly do anything else but teach it the way it has already been set up.
- The YET is pressured to do research and advanced study on top of his all-too-large teaching load. He is rarely encouraged to do research in the development of the laboratory or course he's teaching.
- The YET has to face the devastating inertia of an engineering faculty body. [This is a group of faculty people who are individually "for it" and collectively "against it." Status quo is its motto—altho it can't agree on what is the status to be quo about.] Here is where the YET learns to put educational problems last and professional problems first.

- There is one thing that "saves-the-day" for all present methods of teaching and tends to belittle any effort to make improvements. This is the fact that no one can prove that a school or individual's teaching program is inferior or superior. Thus, if your catalog checks with his pretty well, you're doing a good job.

All these frustrations "uneager-the-beaver." Teaching the course becomes an automatic habit and attentions are put elsewhere. Soon, he is even "bucking" a change because it would "shake-up" a comfortable teaching routine. It's amazing how a comfortable routine makes it right—tried and true!

It is too bad that engineering colleges aren't faced with a terrific competition to place their graduates. If competition existed to the extent it does in industry for the sale of the product, we would have no traditionalism and "status-quoism." If a school's graduates couldn't get hired because their training was inferior—there would be some real "hot" activity to revise the courses, invent new techniques of presentation, revise the curriculum, revamp the labs—jack up the faculty—get new texts, etc., etc.

In spite of all the discouragement that is presented to the YET who is moved to do some experimental teaching, some still try it and we slowly move ahead. We need more teachers to get in and "mix-it-up" in spite of the hostile environment. One of the best things that could happen to the teaching profession would be to have every YET revamp his course this next fall.

Throw out your notes and start from scratch—try a different emphasis—try a new technique! Rattle the old harness and shake off some of the dust! You'll find your work will be more interesting and you may even startle a few people. Who knows, you might do us all some good.—LH

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Here's your YET-itude for June: Change it! Even if it's wrong! Progress was never made standing still!

ANNUAL MEETING

June 25-29, 1956

Iowa State College

Ames Iowa

Are Graduate Courses Millstones or Milestones?*

By L. L. OTTO

Professor of Mechanical Engineering, Michigan State College

Practically all of the engineering teachers who are now teaching graduate courses have worked their way up to that position by serving an apprenticeship at the undergraduate level. The usual pattern of a new entrant into the teaching profession includes a period as an instructor in one or more sections of a many-sectioned course where he may profit by association with older, more-experienced teachers in the same course, followed by a period in which he is given jurisdiction over and responsibility for a course or series of related courses. After this training period he reaches the point at which his teaching experience, his greater maturity in the general field of teaching, and his broad acquaintance with theory and application in a given engineering field, qualify him as capable of teaching graduate courses in that field.

If, after reaching this advanced attainment level he establishes or takes over a successful graduate course or courses he should feel that he has passed a milestone in his career as an engineering teacher, and in his value to the school for which he serves.

The co-existence of graduate and undergraduate courses in an engineering college gives rise to many advantages, both tangible and intangible, and to a few minor disadvantages. There is no other comparable way in which a young engineering graduate who aspires to become an engineering teacher can simultaneously earn the advanced degrees which the teaching profession presently demands of its members, and also come into intimate contact with the teaching methods used by the leading practitioners of the teaching art in its engineering phases. The close contact usually afforded by smaller graduate-course registration gives the professor a better oportunity to evaluate the possible teaching aptitude of the graduate student. If, by good fortune, the student is also a graduate teaching assistant, both student and faculty have an excellent chance to observe and evaluate each other with beneficial results to both. The student has an opportunity to experience both the thrill of feeling a class respond to his efforts at leading their reasoning processes, and the responsibility of presenting a planned, progressive program for successive periods. This opportunity helps to separate the sheep from the goats. The half-hearted and undecided aspiring teacher is discouraged by the responsibility and its accompanying labor, whereas the able, conscientious teaching assistant takes these things in his stride and is strengthened in his intention to become a teacher. This early selection and elimination process is of great value to the schools and to the subsequent career of the student.

The less tangible benefits of co-existent graduate and undergraduate courses are nevertheless real to both students and faculty. The presence in the laboratories of advanced work is a stimulus to the undergraduate student by actually showing him that individual and advanced research can be carried on by

* Presented at the Annual Meeting of ASEE, Educational Methods Division, University of Illinois, June 15, 1954.

others trained in the same curriculum he is following. His interest in, and appreciation of his present work is heightened thereby. The presence on the blackboard from a preceding graduate class of advanced applications and extensions of principles which the senior undergraduate is just then beginning to understand may show in some small way the fact that there are things to learn beyond the Bachelor's degree, and that it might be to the senior's advantage to continue his education after graduation and advance in his learning processes as a graduate student, as an extension student, or on his own. If this thought could be instilled strongly into the minds of our senior undergraduates a great deal of benefit would have been done.

The preceding discussion would indicate that the development of an adequate group of graduate courses was a definite milestone to a school, and to the teacher who participates in these courses. Before drawing final conclusions on the subject, however, I wish to elaborate on the relationship which exists between graduate courses and the person who teaches them. During the years in which I have been involved in teaching graduate-level courses in engineering I have often tried to determine for myself the relationship between the effort required to present the course and the possible reward which might return to the teacher. I have tried to evaluate my own attitude with respect to graduate courses and also that of others with whom I have discussed this situation at various educational meetings in the east and midwest. Among college teachers I have observed an attitude toward the teaching of graduate courses which varies all the way from resentment toward the work involved in a graduate course up to gratitude for the oportunity to teach a course at an advanced level to students who are really interested in what the teacher has to offer.

Personally I feel that anyone who is to make a success of graduate teaching must have an attitude toward these courses which lies at the latter extreme. For his own good, and for the good of his students he should honestly feel that graduate teaching represents an opportunity for him to be of real service to a selected group of superior students, to his own career, and to the school at which he teaches. If this is his attitude the work involved in preparing material which will hold the interest of the superior students will be accepted as necessary and desirable, and laborious though it may be it will never become a chore.

If the teacher's attitude is one of resentment at the amount of work involved in a graduate course, he might better be relegated to the teaching of less important courses, or in extreme cases to be eased out of teaching entirely.

Ample Fund of Enthusiasm Necessary

The benefit from graduate courses which accrues to the teacher and to the student is almost in direct proportion to the enthusiasm which the teacher puts into the course. Enthusiasm is contagious, it can be transmitted from teacher to student, and vice versa, to the mutual benefit of both.

The amount of effort required on the part of the teacher to carry on a graduate course program varies tremendously. Some teachers are fortunate enough to have handed to them a ready made program which someone else has built up into a popular or necessary course sequence, and for which adequate text material is readily available. In these fortunate circumstances the teacher needs only to bring to the course a thorough knowledge of the course material and its relation to other courses, and an ample fund of enthusiasm to rub off on the students. If this is done carefully the course should remain popular and be counted as part of the regular teaching load of its instructor.

Unfortunately this situation does not

always occur, and some teachers find themselves faced with a tremendous problem in their attempts to establish a graduate course or sequence of courses. To begin with there may be only a few graduate students at the school who have the necessary prerequisites and field of interest. Unless he can persuade all of these students, and possibly some others in addition, to take the course for credit during the same term, the number registered for the course will be below the required minimum, and he will get no credit on his teaching load for all the work he will have to do. Also there may be no suitable textbook available for the material he desires to cover, and he will have to supply the necessary information from his own notes and writings. This is almost equivalent to the writing the textbook and teaching the course simultaneously. Under these conditions even the best and most enthusiastic teacher, when harassed by committee assignments, building plans, personnel problems, and a heavy teaching load, will sometimes question the advisability of carrying on a graduate program in the face of such odds.

The fact that many teachers do struggle on against just such difficulties must in itself provide sufficient evidence that the opoprtunity to teach graduate courses is considered desirable. Graduate courses offer some things which the required undergraduate courses cannot offer. Most graduate courses are elective in nature and are taken only by students with special interests in the material covered by the course. In addition to this special motivation the graduate student usually has a better background in math, mechanics, thermodynamics, and related subjects, and is emotionally more mature than the undergraduate, so he will undertake successfully the more advanced and interesting phases of a subject which the undergraduate will not even attempt.

Furthermore a graduate course in most fields of engineering gives a teacher an opportunity to present to a critical but sympathetic audience any new material or new techniques which he has developed, and to obtain an audience reaction to his presentation at a time when any necessary corrective measures may be easily taken.

Last but not least is the opportunity to train the men who must take over the assignment of teaching future generations when he is ready to pass along that responsibility, and to repay in some measure the debt which he owes to previous professors who guided his own early graduate days.

Any of us who look upon graduate courses as a necessary evil, to be endured like any other required chore, have lost sight of the human benefits which can be gained from them. Unlike those people who expect to obtain their reward after they reach heaven, the teacher of a successful graduate course can obtain this satisfaction by observing with pride the progress of the boys he helped to train, and enjoying the warm friendships created in the process. Such a teacher will look back on his progression to the field of graduate courses as the opening of an opportunity, and the question of millstones versus milestones will have received its proper answer.

Education for Creativity in Engineering

(with the aid of six pairs of I's)

By M. S. GJESDAHL

Professor of Mechanical Engineering, Pennsylvania State University

Recently a newspaper article appeared outlining the educational steps involved in teaching creativity in art among young children in elementary schools. The article stated that it was deplorable for a proud father to buy coloring books for his youngster because this left no incentive or ingenuity to be supplied. Great strides are being made in creativity in art with youngsters.

Likewise, in home economics education, the student is encouraged to be creative, original and distinctive, in design and styling as applied to feminine attire. The results of effort in creativity are often quite revealing.

Inventive technique or creativity in engineering is possible without formal training. We are now trying to formalize the pattern or technique which has been practiced by individuals who had a limited amount of education and who developed successful procedures for creativity. Thomas Alva Edison concentrated his time and effort on the *development* of an idea which his mental curiosity had aroused and which his mental habit would not allow to become dormant. His formal education was interrupted at an early age yet he trained himself in creativity by study, experimenting and an insatiable desire to solve a problem and make it work. Likewise Charles F. Kettering failed to complete his academic career in engineering. He, too, developed a philosophy and an approach to problems, particularly in the automotive industry.

In recent years several large companies have instituted programs which train in creative thinking. The General Electric Company is well known for its Creative Engineering Program. In these programs young engineers are encouraged to develop their capacity for the solution of problems or projects which may be new, which may have been tried before and given up, or which somebody said could not be done.

Sometimes age is unnecessarily effective in diluting enthusiasm. As Alex F. Osborn, an advertising executive, and author of an excellent book entitled, "Applied Imagination," says, "Older leaders must especially guard against letting their long experience make them cynical toward ideas which might seem unpromising at first blush. So warns Clarence Francis, head of General Foods: 'Younger executives come to me with what they think are new ideas. Out of my experience I could tell them why their ideas will not succeed. Instead of talking them out of their ideas, I have suggested that they be tried out in test areas in order to minimize losses. The joke of it is that half the time these youthful ideas, which I might have nipped in the bud, turn out either to be successful or to lead to other ideas that are successful. The point I have overlooked was that while the idea was not new, the conditions under which the idea was to be carried out were materially different.'"

One of the basic requirements for consideration of Education for Creativity is an unhibited mind. How often it is noted that an individual untrained in the sciences and engineering asks the

searching question, "Why doesn't somebody develop a method or a gadget to do thus and so?" Right there is an idea for creativity. A need has been suggested.

Engineering education, in the final analysis, is dependent to a large degree upon the developments of the past and the experience and academic training of those who teach. Many industries, in recent years, have requested engineering faculty members to render assistance on problems for which their own engineers do not have time or are incapable of solving. The approach to an unusual problem, which the instructor uses, is the approach which students in engineering need to learn something about.

It is possible by dint of hard work (which is required) to develop techniques in creativity by individual effort. However, companies obtain fruitful results by group effort concentrating thought on a project or program. The suggestion box in a manufacturing plant is an example of encouraged group effort.

Developing Creative Ability

What factors are important in developing creative ability? The mental processes in proceeding from the known are fundamental in scientific training. Combined with an insatiable curiosity and imagination, acquired academic knowledge leads to development along new paths. A sense of dissatisfaction with routine procedure is helpful. Suppose this line of thought is applied to engineering education.

Let us assume that a group of students have a foundation of basic engineering education (if such a premise is valid) or rather let us assume our candidates are ready to begin their fourth year in engineering. Up to the present time, academically very little integration of the various courses in a curriculum has been evident. Facility in mathematics, an absorption of physical laws, a little dab of service courses in other curricula added to the main stem courses —and so we have fourth year students with a mental basketful of packaged courses. In another 32 weeks, these students are separated from the cloistered protection of prepared lesson assignments with known answers to many more or less carefully prepared problems. Fundamental, yes, but what inspiration for creativity exists in such a traditionally operated sequence of educational steps? Even our examinations are slanted toward a pattern solution because all answers should agree with our own to a certain decimal point.

In what way may the concept of creativity, imagination or inventiveness be applied in each course? As the fundamentals of descriptive geometry, mathematics, physics, mechanics are covered, is the main emphasis in these courses a question of quantity or efficiency of absorption at the close of an academic year? Do we conclude with a mental sponge more or less fully absorbed with droplets of engineering data in a metastable state, or have we developed a reservoir of fissionable material which requires only a state of unsettled impatience or ingenuity to gender a chain reaction resulting in a capacity for creativity or scientific development?

Practical Creativity

Mr. E. K. Von Fange of the General Electric Company has the following to say about college training. "The usual college training adversely affects creativity. For example, the assignments given in a typical engineering institution might be likened to a foot-bridge swinging and swaying across a rather wide and deep chasm. The problem is the bridge. At the other end of the bridge lies the solution. Strong and sturdy guide rails are formed by the detailed definition, boundary conditions, the applicable formulas or procedures given in the text, etc. As the student goes through his years of education, he is sent across progressively longer

bridges, though each is still adequately protected by guard rails, and he has little difficulty. Then, upon graduation, the guard rails are removed and he is told his sheepskin equips him well to start across the bridge. Small wonder that engineers, new to industry, are a bit hesitant and undecided about what to do and how to go about it! And small wonder, too, that they learn to use the safely guarded bridges of the conventional in their engineering career and refuse to cross a creative bridge even if they do see it, simply because it has no guard rails to lead and guide them."

For the past few years, in applied machine design with sixth semester juniors in mechanical engineering we have assigned a term problem, allowing about ten weeks of the total sixteen weeks on the problem. Last semester the problem involved the design of a dual-purpose electric motor driven impact tool for power screwdriving and for power hammering or chiselling. A combination tool of this sort is not on the market. The specifications among other items included a computation notebook showing the evolution of the tool design with all sketches made of proposed mechanisms and structural details whether or not they appear in the final design, all calculations made to justify sizes and proportions of the critical parts of the tool, and references from catalog literature indicating selection of commercially available parts. The final design was presented in a layout assembly drawing of the proposed power tool on 17 by 22 vellum paper. Sufficient views and sections to describe its external appearance as well as the internal construction and arrangement of parts were required.

During the last week of the semester each student was given an opportunity, in ten minutes, to describe his design to a panel of three instructors, one of whom was his own in the design course. Then, he was questioned by the panel and he was required to justify and clarify features which were ambiguous or erroneous. Each member of the panel evaluated the design on the basis of originality and presentation, engineering design and production.

The comment so often made by the students at the end of the semester is that they used much of their previous training and that they "were really on their own." The instructor serves as an advisor and encourages the exploration of an idea which the student offers in the design project. It is enlightening to the instructors who must consider design problems with the students. Of course, a few try to lean on the experience and judgment of the teacher. Self-reliance does not come easily to some.

Six Pairs of I's

In considering education for creativity, six pairs of I's seem to be basic. They may be applied by student and teacher alike.

Creative Thinking is a concatenation of three pairs of I's, that is, of Imagination and Ideas, Incentive and Initiative, and Illumination and Inspiration. The result of insight with I's such as these leads to Creativity through the other three pairs of I's, namely; Information and Intelligence, Investigation and Interpretation, and finally Invention and Improvement. The use of these six pairs of I's on any problem or project should yield, in appropriate time, a solution or result which may be said to be creative. The acquisition of, or the encouragement to get, an ability to think and act creatively is an important aim of education in engineering.

Suppose each one of us were given the problem of designing a safety device for refrigerators, the household type, so that a youngster who may have been shut inside by playmates could by some means unlatch the door. Try and apply the six pairs of I's to such a problem.

The August 1946 issue of *Mechanical Engineering* contained an article by Wil-

liam H. Easton entitled "Creative Thinking and How to Develop It." In this excellent article, among other important statements, he says, "There are three creative processes which are used by every thinker. These are: *Imagination,* which is the power that enables a thinker to weave ideas into new combinations while he is engaged in deliberate thinking. It usually deals with easily remembered ideas. *Inspiration,* which is the result of an accidental stimulus. It occurs when new ideas derived from some observed object or circumstance suddenly and automatically combine with old ideas. *Illumination,* which is evoked by intense deliberate thinking and forms new combinations of ideas after the thinking has ceased. It resembles inspiration in occurring without present effort, but has an entirely different cause. It frequently brings to the surface long-forgotten ideas." Note the I's in the quote just given.

In a sport, whether played singly or on a team, after we have learned the rules and rudiments of performance, we try to outmaneuver the opponent with imagination and the unexpected. Creativity is like that. It is trying the untried, asking why not, making assumptions—radical ones, using past experience and present needs to generate ideas. As in a game, it requires effort to win.

A high-grade cabinet maker became skillful because he first learned the proper use of his tools, so that each tool would perform in accordance with his designed effort. The fact that he is a high-grade cabinet maker is not due to his *possession* of the tools, but due to his ability to apply them as needed. His inspiration and ingenuity produce the difference between excellence and mediocrity.

Thus in training engineers though we may supply the necessary tools of the profession by our educational process, it is essential to instill that ingredient or spark which sharpens the imagination with the intellect.

In evaluating our perspective of engineering programs, our teaching techniques and integration of course content, it is our goal to develop well-prepared, confident, inspired, *creative* young engineers. Of such, there is a great need.

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The Education of Leaders*

By ROBERT B. DAVIS

Assistant Professor of Mathematics, University of New Hampshire

Sometimes philosophy is important.

I have seen students required to take courses which are worthless to them. This, unfortunately, *does* happen, and often on rather a large scale. It is defended by saying that the course has always been required, or prehaps it is defended by saying that *many* students need the course, or perhaps it is defended by saying that one must learn trigonometry quite thoroughly before one is prepared to go on to calculus. I have heard courses in analytic geometry defended by the statement that they are "not without interest."

All this is a question of judgment, and it is often hard to put one's finger on the root of the matter. In any question of judgment, we need to know all of the facts. It does not do to dispense judgment at a distance, and one has to be careful not to talk in empty generalities.

Nonetheless, in a precise, concrete way, making due allowance for the delicate judgment involved, I find that I am shocked at some of the philosophy which I have encountered in academic circles.

There is the philosophy of uniformity. We must treat everyone *exactly the same.* Not fairly. We cannot treat everyone fairly if we are to treat everyone the same, because students are not identical when they come to us, when they register for our first-term freshman courses. The one student knows trigonometry well. The next does not. The one is eager, the next is lazy.

But I have frequently heard faculty members say that we must treat everyone the same. And they meant exactly that! This student got a 59 in our course, and so did that one. We *must* treat them the same. No matter that student A has been out of school for years, has never had a strong high school background, has worked hard all term, has been hampered by the illness of his wife, but nonetheless shows unmistakable signs of the maturity and good judgment which promise to make him a good civil engineer, let's say. No matter that student B came with a good background of factual knowledge, refused to believe that there was anything he did not already know, and in fact finally stopped attending class altogether. No matter that student A made nearly 60 in every quiz all term, while student B's record began with 90's and ended with zeros. They both ended up with an average of 59! Treat them both the same! For both diseases we have the single remedy: students A and B will repeat the course next term!

No matter that, as a civil engineer, student A will not really require this course in his later professional work, whereas student B, in his work, will.

I know perfectly well where this philosophy of uniformity comes from. It is the offspring of another pernicious idea: the idea that we must avoid criticism above all else. Like the politician who prefers doing nothing, because doing anything at all will create some enemies, we faculty members often act as if we are quite prepared to see our curriculum become outdated, rather than risk criticism. If we do this year what we did last year, we shall have a precedent, and

* This paper won second prize in the 1954 Y.E.T. contest.

a precedent, in academic circles, is the best possible answer to criticism. Logically it is an unacceptable answer altogether: a precedent, logically, means that either one was making the same mistake already last year, or else, perhaps, one is refusing to seek improvement or even to keep abreast of change. But *de facto* it is the best answer of all. Just say: "Why, we have *always* done it that way!"

I think we must be willing to experiment, and at a good rate, too. We cannot sit in last year's ivory tower and concentrate on avoiding criticism.

Let me return to the required courses which I mentioned earlier:

Does one learn trigonometry thoroughly, and *then* learn calculus? I say emphatically one does not. No student who has just completed a course in trigonometry for the first time is already the complete master of the subject. *Working with* trigonometry, subsequently, is what drives it home. Yet we often divide the curriculum into vertical segments with far too much separation, and require an unrealistic degree of mastery at each step before allowing the student access to the next higher step in the ladder.

We also divide the curriculum into horizontal segments, and teach—for one example—integration as a dull (and difficult) mathematical technique, where the practically-minded student finds little to seize hold of. We teach differential equations as a separate subject. The study of beam bending is again separate. Yet these three areas can be effectively combined, in a certain sense. Not necessarily that the three courses should be replaced by one. There is too much material in them for that to be possible. But combination of a sort is possible and extremely effective.

One can walk into a class in Integral Calculus, and ask the question: if a beam is to be loaded uniformly, will we be less in danger of breakage if the ends are rigidly fastened, or if they are free to pivot? I know how well this type of integration can work ("integration," that is, in the sense of tieing subject matter together, not in the sense of un-differentiating a differential), because I have tried it. I have asked precisely this question, to a class of students armed only with their Integral Calculus texts. Some of the problems at the end of the chapter, in the text, contained all the theory that was needed.

And the technique worked magnificently!

The students had expected me to come in and spend the period evaluating integrals like

$$\int \cos^4 x \sin^4 x \, dx.$$

They expected me to stand there and write formulas all over the blackboard while they waited impatiently for the end of the hour. They were quite excited by the idea that simple reality questions had a proper place in a "dull" math course. Moreover, I am sure that they were excited by the idea that I could treat them as engineers, and ask a simple question, leaving to them the task of locating the proper section in the text, leaving to them the problem of achieving a suitable mathematical formulation, and leaving to them the proper interpretation of the mathematical result.

Frankly I am proud of that episode. Because it was much more than one hour's work. If I had not prepared a suitable atmosphere earlier in the course, if I had not shown the students that I had confidence in their ability to get along with a minimum of help from me, the result would have been dismal, not triumphant. I would have asked the question . . .

. . . and the room would have been filled with a beautiful, tranquil silence, but no sound whatever of an answer.

Dependent Relationship

I have another class, on a more advanced level, where it is much more difficult for me to persuade the class to give up their passive dependence on me. Of course I want them to feel that I am there ready to help them, at any time when I am actually needed. But I want them to learn that they can get on without me. I want them to know that I have confidence in them, and that I am not indispensable. And I want them to learn confidence in themselves. We have made progress in this class, these students and I, but there is still a long way for us to go. The students are beginning to believe that my confidence in them is genuine, but they are still somewhat uncertain whether or not they deserve it. We shall have to show that they do.

This is a very delicate area. It is not a trivial question, the proper handling of the student's dependence. The student must get support from the teacher, but he must learn to stand on his own two feet out of the simple joy of doing it. He must come to stand on his own feet because he really wants to—not because he has been thoughtlessly pushed into such a posture.

In handling this dependent relationship, the teacher is called upon to display the delicate skill of a surgeon—and not the all-too-frequent technique of a pedagogical butcher.

Let me list some more philosophies which I think are dangerously false:

False Philosophy No. 317: The students must be told exactly what to do, how to do it, when to do it, and—afterwards—how well they have done it.

(I say NO, four times!)

False Philosophy No. 321–D: Education is like medicine; if it isn't unpleasant, it isn't really doing much good.

(On this I carefully refrain from making comment, in order not to depart from the generally discreet tone of the present communication.)

False Philosophy No. 407–XHF: Industry wants obedient engineers.

(I say . . .Oh, excuse me. Let's just say: "Industry, as nearly as I can tell, does not want men who expect to be told what to do and how and when to do it. Industry wants men with initiative . . .

. . . that means men who *decide* for themselves, who can act on their own decisions—and, of course, men who get along well with others, who cooperate in organizational manoeuvers, who see things in context—men who will see the possibilities inherent in something new—men for whom the future is something exciting and different . . .

. . . and you don't train men like that by telling them what to do for four years. You don't train men like that unless you, as their teacher, are pleased to regard yourself as just barely necessary—not indispensable—and are honestly convinced that, as students, they *can* do things by themselves. You have to respect their judgment, and you have to recognize and respect their motivation.)

Initiative is never going to line up and get a serial number, and you can't train it that way, either. That way, you can only kill it before it even gets started.

Let me, finally, return once more to our earlier discussion of required courses. Why is analytic geometry required? Its subject matter is so intermingled with that of calculus, and with the elementary notions of vector analysis, that a much smoother "unified" course can be created, instead of teaching all of these subjects separately. In doing so one leaves out, to be sure, certain highly specialized topics in analytic geometry. These omitted topics, however, are almost never useful. It is true that in studying them, the student does get some additional training in mathematical manipulation, which is of course valuable. I admit that, but . . .

. . . But aren't we also, in analytic

geometry courses, teaching the student that mathematics is a dull and difficult game which has little to do with reality?

This notion is widely held among engineers. It is untrue. Yet it must come from somewhere. I would say that it comes from the *organization* of our mathematical curriculum, from the *way* in which math is presented, from the unfortunate separation which we make, between math and the other engineering and science courses. Even the physicist, who ought to be working hand in hand with the mathematician, tends to regard the mathematician as someone vaguely impractical, more concerned with formalisms than with practical accomplishments. How are we to bring the curriculum back together again?

If we want to teach the student some mathematical technique, is it not better to teach him the manipulation of mathematical materials which are still alive, rather than the dried-up, desiccated particularities of many analytic geometry courses? Who cares what a *latus rectum* is? The *standard deviation* would be more to the point.

We could eliminate analytic geometry, move the courses forward, and make room for a better course in differential equations, or for a course in Bessel functions and partial differential equations arising in engineering, or a course in numerical and graphical methods, or perhaps even a good course in probability and statistics.

This would be exciting material. And one could make sure that such a course was generously sprinkled with current engineering applications that would help the student to tie his entire education a bit more closely together.

And, of course, the mastery of manipulation would still be present, just as much so as in analytic geometry.

Although I shall not dwell on it, this is in fact another question of philosophy. When someone says "this course is not without value," I find myself thinking:

"Yes, but what else might be better?"

I think the universities need to cultivate a greater realization that they deal in an economy of scarce means. There are just so many class hours available, just so many rooms and so many teachers, just so many years in the students' lives, just so much mental effort per student. Not an unlimited amount of time, nor an unlimited amount of mental effort. We *say* that we recognize this. But do we, when our curriculum includes the *latus rectum* of analytic geometry, with no apparent awareness of all the more important material which is being left out?

Please do not misunderstand me. I do not refer only to analytic geometry. I refer to all of the material of secondary interest which is permitted to fill our curricula, excluding material of primary interest. We are well able to see the exclusion principle in quantum mechanics. Why can't we see it in our university curricula?

I refer to all of the special *little* items that have excluded more important *general* questions. Analytic geometry is merely one case in point.

And since we have said that philosophy is important, I wish I could find, also, the proper way to ask the following question. I would like to ask every teacher who leads the student every step of the way, who feels the student could not make it by himself, this:

"Why?"

"Why do you think the student incapable of getting along by himself? He can organize his own clubs, can't he? When he goes astray, a youth can organize a band of others, and devise all manner of nefarious activity, much of it highly ingenious. Students can learn subjects, such as electronics or music or the art of writing short stories, entirely by themselves, in their spare time, if the fancy hits them. Why, then, do you feel that students must be led

carefully along? I say that the job of the teacher is to inspire the student, then let him go by himself."

It seems to me that the teacher who leads every step of the way is afraid. He is afraid that the student will be able to go on without him.

Or perhaps such a teacher is just lazy. It is so easy to lecture to one's audience (Merciful Heavens! Am I doing that in this article?), without admitting that *the audience* (a phrase which sounds impersonal) is actually a group of fifteen or twenty human beings, each of them quite different from all of the others, each of them having feelings, passing judgments, making decisions, and acting on their own (even if their only decision is to cut class as often as they can.) Is the teacher who delivers dull, routine, rote lectures really *aware* of these twenty human beings, and of all the potentialities within each of them? Is he permitting himself to recognize the myriad complexities of their various futures? All of the things they will do, or will fail to do, during the next fifty or sixty years or so?

Why on earth do teachers want to be textbooks?

Conclusion

It seems to me that all of us who are faculty members need to work honestly —and with some definite determination —to create and maintain a certain desirable atmosphere in our schools. An atmosphere, that is, that aims at training leaders, not meekly submissive robots; an atmosphere that sees the teacher as someone who is there to help, not to threaten or to criticize; an atmosphere that respects the student's ability to think for himself; an atmosphere that is lively and changing, that views a new and different tomorrow as a thing of exciting promise, not a dangerous departure from the dull repetitions of all of our yesterdays. An atmosphere, that is, of science, creativity, maturity, and emotional warmth.

An atmosphere, that is to say, of happiness, growth, and progress.

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Unionization of Engineers—A Reexamination

By GLENN W. MILLER

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In the December, 1954, issue of this Journal two authors took a very strong position to the effect that professional behavior and attitudes to be expected of engineers are incompatible with membership in a union. Mr. Clarence T. Shock and Mr. A. A. K. Booth approached the subject from different angles but arrived at much the same conclusion. Both discussions are founded on value judgments as to the motivation and behavior of union members. However, many of these concepts seem to spring from the atypical (but well publicized) actions of some unions and unionists. These ideas merit further examination if those who read the Journal wish to examine all sides of the question of unionization of engineers.

Early in his discussion Mr. Shock refers to "the philosophy . . . of collective bargaining" and comments immediately that "the words have a sinister sound to us, and portend a situation in engineering circles totally foreign to the generally accepted philosophy of a professional man." It is to be presumed that the sinister sound heard by Mr. Shock echoed from the word "bargaining" rather than from the word "collective." Mr. Shock wrote as an officer of an engineering society; the very existence of such a society indicates action by the group (i.e., collective action) to achieve certain agreed upon goals. Evidently there is a line to be drawn between the activities in which engineers (and other professionals) may engage collectively and those actions still in the preserve of individual action. The question is where this line of demarcation shall be drawn.

The writer would be the last to suggest any weakening of an attitude of genuine professionalism within any group. However, it seems that the ego-satisfaction that may come from membership in a relatively small, elite group often is mistaken for professionalism. Along with a skill or ability possessed by relatively few, professionalism carries with it a certain philosophy which is "fundamentally eulogistic." * Both the search for ego-satisfaction and the eulogizing of the profession are pseudo-professionalism to be contrasted with the genuine professionalism which is characterized by competence in a chosen field, intellectual curiosity, and willingness to devote much time and effort in the use of one's special abilities for the improvement of society. Perhaps this tendency to eulogize the profession is one of the most important factors creating the philosophical breach between many "professionals" and "labor." As long as the professional considers himself in a group apart (and also fails to understand more about organized labor) then techniques that may be used by large numbers probably will not be accepted.

Not all professional groups hold the opinion that union membership contradicts professionalism. Musicians, actors, and newspaper reporters, are examples. Air line pilots have their own union that bargains collectively. Engineers may argue that the examples cited are not professionals to the same degree that they (the engineers) are. However, the eulogistic philosophy of the professional

* Northrup, H. R., "Industrial Relations with Professional Workers," Harvard Business Review, Vol. XXVI, No. 5, September, 1948, p. 543.

should be kept in mind. The reporter, musician, or pilot will be able to argue the peculiar importance, and professionalism, of his job. Even so, many of them have turned to collective economic action.

Mr. Shock is of the opinion that "our immediate problem really has little to do with employers or employees as such." Evidently in his point of view engineering employees stand alongside management pursuing similar goals along the same paths. From this point of view flows the attitude that an organization of engineering employees to pursue the goals of employees is indefensible. Taking as his *bete noir* the Engineers and Scientists of America, he states "we are apprehensive . . . of the stated aims and objectives of this organization, which are at extreme variance with the more altruistic motives expressed by the long established professional engineering societies." Subsequently, he expresses his bewilderment "how has the engineering profession been maneuvred into this peculiarly contradictory situation of professing on the one hand to devote its combined talents to the benefit of mankind, and on the other, to foster activities which are extremely controversial as to their public interest value?"

This apprehension and perplexity is unwarranted. Any form of behavior can be found in the labor movement of the United States. A person can find examples to emphasize his greatest fear or to support his most optimistic viewpoint. Much depends on what the observer wants to see. The labor movement in the United States is some 150 years old and 17,000,000 strong. Taken as a whole it has a proud history; it has been in the forefront of the struggles for many of the social and political institutions that we enjoy now such as free public schools, abolition of imprisonment for debt, child labor legislation, social security measures, minimum wage laws and the like. Indeed organized labor has been one of the strong and consistent supporters of the democratic way of life.† While there is no doubt that Mr. Shock and others can find examples of union behavior to bolster their fears, examples which the bulk of the labor movement itself decries, the typical behavior of unions is quite a different story.

Strike Activities

Engineers are disturbed by the potentiality of strikes and other coercive activities of unions. Mr. Shock refers to "the usual methods of unions (coercion, strikes, picketing, closed shop, etc.)" Mr. Booth notes with disapproval the strike action of one group of engineers. Again the misgivings are not well-founded. In industries covered by the Taft-Hartley Act, the closed shop has been unlawful for nearly eight years, so it hardly merits the adjective "usual." As for strikes they are not a usual method. In only two years in our history have the numbers of workers engaged in strikes exceeded 3,500,000; post World War II years show an average of fewer than 3,000,000 strikers. These figures may be compared with a labor force now totalling nearly 65,000,000 and a union membership of about 17,000,000. In most years the percentage of estimated working time lost because of strikes is less than one-half of one percent.‡ Engineers seem especially to decry the strike weapon. While their reasons may be different, most workers also are opposed to striking if it possibly can be avoided. Strikes cost individual members who are involved and unions large sums of money; they are embarked upon reluctantly. The publicity given to labor disputes and the little attention paid to peaceful labor relations has done much to

† Millis, H. A., and Montgomery, R. E., "Organized Labor," McGraw-Hill Book Co., New York, 1945, Chs. I through V. See also Dankert, C. E., "Contemporary Unionism in the United States," New York, Prentice-Hall, Inc., 1948, passim.

‡ For current data on work stoppages see *Monthly Labor Review* issued monthly by the U. S. Department of Labor.

foster an erroneous impression of the inclination of unions and their members to strike.

Still another comment is relevant to the strike fears of engineers. It is almost unheard of for a strike to be called just to create excitement, to harm or destroy an employer, or for any such type of reason. A work stoppage occurs when workers and management can not agree on terms or conditions of employment. Let us take a very simple example. A union asks an employer to pay $2.00 per hour for a certain type of labor; the employer will offer no more than $1.85 and a work stoppage ensues. Both parties want work to continue—under the conditions that they are backing. Strictly speaking there is a *strike* against working at $1.85 per hour and a *lockout* against work at $2.00 an hour; use of the term "strike" is unfortunate since the label suggests that the union is responsible.

Mr. Shock is of the opinion that "unionization places sole emphasis on wages and hours, and on union membership." Probably unions always will put considerable attention and effort on the subjects mentioned. However, to imply that the "sole emphasis" is as suggested is to ignore many problems on which unions spend much time. Representing workers in the handling of grievances, working on problems of health and safety, negotiating on subjects such as vacations and sick leave are only a few examples of the many issues beyond wages, hours, and membership in which unions are interested. Some activities of unions today go well beyond the work-place and into the communities in which we live.

Many of the activities of present-day unions are not of primary benefit to their own members. Support of a minimum wage law will be an aid to workers with low incomes who are likely to be unorganized. Support of a United Appeals campaign or a blood donor program are other examples. Standing squarely behind the philosophy of intellectual freedom when it is threatened in a college or university takes union organizations still farther afield. The list of such "extra-curricular" actions of unions could be expanded greatly.

Most engineers are inclined toward a pro-management point of view. Since World War II the writer has conducted two or three classes each year in labor problems for engineering students; their pro-management attitude is clear, although they do not differ greatly in this respect from other university students. Messrs. Shock and Booth strongly support this management orientation. Arising from this attitude, there is a reluctance to think of engineers as employees.

Recent studies (not centered on engineers, it is true) suggest clearly that union membership does not destroy loyalty to the employer.§ There is no reason why the engineer who chooses to join a union cannot remain loyal to the company and continue to command the trust and respect of management. Most of us have multiple loyalties—perhaps to family, church, lodge, friends, professional groups, unions, employers, political parties, and the like. The motivations and goals of such groups will not coincide always, and choices will have to be made. But membership in one group or association does not necessitate disloyalty to some other institution whose aims or goals may be somewhat different. It may call for accommodation or compromise, but such is life. The aims of management and employees may diverge (especially in the short run) but they are not unalterably opposed. Satisfactory working arrangements can be and are worked out day after day.

Employee Status of Engineers

As to the employee status of engineers, the American Federation of Technical

§ Purcell, T. V., "The Worker Speaks His Mind on Company and Union," Cambridge, Harvard University Press, 1953. See also "Dual Allegiance to Union and Management" (A symposium), University of Illinois Bulletin, Vol. 51, No. 79, July, 1954.

Engineers (A.F. of L.) comments "in America today, over 90 per cent of all technically trained persons are employed on a salary basis. . . . This condition is the result of the transition of industry from single ownership to the corporate type of collective ownership. This growth of industry has directly affected the status of the engineer. . . . It has created the Employee-Engineer." ‖

If the typical engineer is an employee, will the type of professional organization used by some other groups meet the needs of engineers? Mr. Booth cites with approval a speech delivered before a branch of the medical profession, and wishes for the same type of professionalism among engineers. It is true that doctors and lawyers affect their economic status through "professional" organizations. However, most doctors work for themselves selling services directly to the public. The economic relationship of a doctor or lawyer to his patient or client is quite different from an employer-employee relationship. In the first place, little bargaining occurs over the price of medical care. If any kind of bargaining were to occur the doctor will be the equal or better of his "employe" or patient; he needs no union to deal for him. Logically he will pattern his group activity after those of the business man. A "trade association" type of group activity may serve adequately the economic interests of the group. On the other hand, employees may need a different kind of organization to serve their economic needs—if they decide that these needs can not be served adequately by their individual efforts.

If groups of engineers were to elect to organize, there is no reason to assume that bargaining done on their behalf would be identical with that of any other union. The issues bargained out and the techniques used vary widely from union to union, depending on the membership and leadership of the union, the attitude of the employers, the problems of the employee group, and the like. George Meany, President of the American Federation of Labor, commented recently on some of the misgivings of engineers regarding unionization: "No other organization or union has any voice in formulating the collective bargaining demands of the American Federation of Technical Engineers, nor are the wage and salary rates for members . . . patterned after the rates or contracts negotiated by any other union. The gains made . . . have not been accomplished at the expense of stifling initiative. . . . Patent rights of members are protected by articles in the contracts." ¶

Engineers themselves must decide on the manner in which they shall pursue their economic interests. Under present federal labor legislation they are free (as long as they conform to the vote of a majority of the bargaining unit) to unionize or stay out of unions. If they choose to unionize, they may do so in a separate group, as long as it is not employer dominated, or as a part of a union that includes employees other than engineers. The choice should not be made lightly, since it calls for a decision as to whether the past philosophy of economic individualism continues to be a desirable guidepost. All relevant information on the issue should be considered. This discussion suggests that, in the past, full and and unbiased information on unions often has been lacking. In making a decision it is suggested that the following propositions be considered as well as those expressed by Messrs. Shoch and Booth:

1. It is becoming increasingly difficult for the individual employee to control his economic life effectively. Opportunities for employment, advancement and the like are affected by many forces besides the efforts and desires of the individual, and beyond the control of the individual.

‖ "Are You Afflicted With Professional Aloofness?," recruiting leaflet issued by the union.

¶ Meany, George, "Engineers Need Unionism," *The American Federationist*, Vol. 62, No. 3, March, 1955, p. 20.

2. Engineers or other groups of professional employees probably will find that professional societies are inept and reticent at representing the economic needs of employees.
3. Many professional workers, engineers included, have joined unions. In most instances these unions have centered around persons of a certain technical or professional knowledge.
4. Membership in a union need not conflict with genuine professionalism although it may tend to reduce the degree of individualism assumed by some to be part and parcel of professionalism.
5. In general, unions do not act in a way that is contrary to the public interest. Examples to the contrary can be cited, but these are not representative of the union movement in the United States.
6. If unions could help engineers to become well-paid and relatively secure in their jobs and economic future, engineers need not lose any of their respect for their profession, their intellectual curiosity, nor their desire to serve in such a way as to build a better tomorrow.

This discussion draws no conclusion as to whether engineers should join unions; that decision is one for the engineers. It is clear, however, that many professionals have a meager and often erroneous impression of unionism in the U. S. today. This paper attempts to clarify some of these misconceptions held by many engineers.

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Some Suggested Changes and Shift of Emphasis in the Engineering Curriculum

By ERIC J. LINDAHL

Head, Mechanical Engineering Department, University of Wyoming

I, for one, would like to feel that the unified curriculum is just around the corner, and it may be for a few institutions, but until a great deal more selling work is done, I think it will be some time before the operation as now practiced in nearly all engineering colleges is abandoned. In the meantime we should look about carefully to see if we can make our present system more efficient by consolidating as many courses as possible and by taking the frills, the non-essentials and overlapping materials out of our present offerings. Only in this way can the four year program be salvaged since there is now no room to add courses and the addition of a new course comes at the expense of some course already in the curriculum. In the small schools, it is also imperative that we make use of our class rooms and instructional staff in a more efficient manner by putting students from several departments into one class as much as possible. If, by a wave of the hand, we can't have everybody taking the same thing, then perhaps a gradual change can be affected by gradual consolidation of the various programs that now exist.

One way to bring about consolidation is to do away with that unpopular thing called the engineering service course. I have found that almost universally these courses are unpopular and dreaded both by the student who takes the course and by the instructor who feels that he is forced to lower himself by teaching the course. The young instructor frequently is caused to teach the service courses and it is no wonder these young men sometimes wonder if they are in the wrong business.

It once fell to my lot to teach separate service courses in heat power for chemical engineers, for civil engineers and for industrial engineers. In each case the first few pages in the text were devoted to elementary thermodynamic equations which were presented in such a sketchy fashion that the poor fellows were left hopelessly confused and bewildered because otherwise worthwhile material received such a "lick and promise" treatment. Certainly they had nothing upon which to build in later years and in my estimation if a course presented in an engineering college cannot be used as a foundation for future study then that course is to be considered useless.

I would suggest that rather than being required to take the special service course, that the students in the other departments take all or part of the same course as the students for which that course is a major.

For one thing I would suggest that all students take the same course in thermodynamics as that which the mechanical engineers are required to take. While it is true that, while there will not be so much application material in this course, that which they do learn they will learn more thoroughly and they will have a foundation upon which to build.

The same is true with mechanical engineers and others taking the beginning course in electrical engineering. At the

present time the work covered is so sketchy that the poor fellows have only the vaguest idea of what is going on and about all they learn is that they have a thorough dislike for anything electrical engineering. What would be wrong with having the mechanicals, civils, and others at least taking the beginning course presented to electrical engineers? Certainly the mechanicals, and perhaps others, need just as thorough a grounding in electrical engineering fundamentals as do the electrical majors.

Out in this Western country it is probably a good idea to have all students, be they civil or otherwise, take a course in surveying. So why should not all students be subjected to the same beginning course?

All schools do not require a course in heating and ventilating for mechanicals but apparently all architectural engineers have to take that course and many institutions have an elective course in heating and ventilating for mechanicals even if it is not required of them. I would again suggest that all people taking the heating and ventilating course be subjected to exactly the same treatment.

At the University of Wyoming we have just finished setting up new curricula since we are changing from the quarter system to the semester system of operation. While I had hoped that many more changes in the departmental curricula could be made, what changes have been made have been brought about in the direction of a unified curriculum.

The students have always taken the same mathematics, physics, chemistry, mechanics, fluid mechanics, and some others and now we have all the students taking the same thermodynamics and have all those requiring heating and ventilating taking exactly the same course. In other words we have done much to eliminate the so-called service course. The thermodynamics course has had a one-year trial and the heating and ventilating course has had a five-year trial. Both have been successful and the only trouble is that the civil engineers make better grades in thermodynamics than do the mechanicals and electricals. The heating and ventilating course taken by both the mechanical engineers and architectural engineers has not suffered materially in rigor over the course formerly given for mechanicals alone and in the combined course the architectural engineers do just as well as the mechanicals. We feel that we have made a right step in eliminating service courses. As I said at the outset we are supposed to give students something upon which they can build in the future and this cannot be done with much success with one of those bobtailed service courses with the theory all covered in the first 15 pages and the rest of the book devoted to thousands of words of description and hundreds of illustrations which are out of date before the ink is dry.

Too Much Material Covered in Textbooks

Another thing that I have been wondering about is why is there so much material covered in every textbook. No matter whether it is a book on power plants or internal combustion engineering or what, there is always a chapter on fuels and combustion. Why is this included here? Could this not be left out of all of them and given in a separate course in combustion? This would cut down the size of many textbooks and thus reduce their cost. I find also that several books have a chapter or two dealing with heat transfer. Most schools have a separate course in heat transfer so why should this material be included in several of the books secured by a student. In general, it is only covered once and that time in the heat transfer course for which a separate text is purchased.

These are only a few examples of stuffing texts and the first question that comes to my mind is whether or not a book has to be fat to be salable. Cannot

good things come in small packages? It has been my experience that all the material cannot be covered in every text anyway so why put so much into them. Every text should not be designed as a reference book or handbook.

I am also wondering if there could not be some realignment of existing courses. For instance, now that courses are given in steam turbines and gas turbines and in some cases hydraulic turbines, centrifugal pumps, fans, blowers, and so forth, the books I have scrutinized have considerable overlapping in the principles of operation of these devices. Perhaps some schools already do this but could not a course be given in rotating machinery which would apply to all these devices. Students have so much trouble carrying principles from one course to the next, perhaps if they could see how basic principles are tied together from one machine to the other, less confusion might result. I have only used one example here and that in mechanical engineering but I feel that other examples and in other departments could be brought to mind. For instance, all types of reciprocating machinery could be covered in a single course.

I believe that we try in all schools and in all departments to cover too much material. Generally speaking, it seems the students have been presented so many things and have such a vague knowledge of what they have learned that they are completely confused and have so very little confidence in what they are able to retain. I feel that many are in the same shape as a friend of mine who remarked on commencement day, "I know nothing and I've got that all mixed up." I think it is high time everyone took a good look at curricula and courses to decide what should be taken out rather than what should be put in. It certainly is true that if we expect to put in something we have to take out a like amount. I would like to see a group of top educators, preferably working through A.S.E.E., make a study and suggest what material and what courses should be deleted and what should be presented. If that were done and if laboratory equipment were prescribed or suggested it would be much easier to plan for an E.C.P.D. visitation and also so much easier to please the E.C.P.D. inspectors.

Before closing I should like to repeat that the material presented to students should be something upon which they can build in the future. While we in engineering should certainly look our courses over and decide what to throw out, I feel that the mathematics people miss the boat here as much or more than anyone else and they could so easily make a change. They try to give too much. The highest compliment I ever heard concerning a mathematics professor was paid to one on our campus when it was stated that this mathematics professor did not try to tell the students everything he knew. Incidentally, this mathematics professor is the most popular man in that department. I have often wondered why mathematics people put in so many extras which appear in the back of the book at the expense of teaching a few things well which appear in the front part of the book. If the procedure were reversed, the students would have a sturdy foundation upon which they could build by either course or individual study.

I dare say that there are students who come into their junior year who have never had pointed out to them which parts of the calculus book they will be needing during the next two years. They never seem to recognize nor are they able to handle the simple basic equations required in the junior and senior years but I think I know the answer why. They have been too busy sitting around watching a mathematics instructor spend hours and hours integrating and differentiating extremely lengthy and complex equations for which they will certainly have no immediate use and which perhaps have very little practical application.

I dare say that engineering sophomores are required to operate with equations which could not be set up by a single living soul in the states of Utah, Wyoming, or Colorado, except by a man who enjoys mathematical gymnastics. I feel that too many teachers, be they mathematics teachers or engineering teachers, are much more interested in teaching their courses than they are in teaching students.

In thinking of the reasons why so few people want to go into engineering teaching, I wonder if it is because we, as their teachers, have done such a rotten job that they do not want to be like us. Perhaps we have given them too much of the wrong thing. Perhaps our courses contain too many uninteresting and unimportant things or perhaps we have given them too much and merely caused them confusion.

I feel that it is high time we do everything we can to place greater emphasis upon basic ideas upon which our students can build in the future.

The Teaching and Learning of Engineering

By ERICH A. FARBER

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Whenever the question of what to teach the students of engineering in their college courses arises, little disagreement is found among educators and professional engineers. Everyone agrees to the magic words "The Fundamentals." When, however, it comes to defining these fundamentals, differences of opinion appear, and it is possible to get answers like "chassis design," "jet propulsion," and other fields of individual interest.

The student, on the other hand, often remarks "Why don't we learn something practical, rather than all this theory?," when his opinion is sought. However, when asked to define what he means by "Something Practical," he becomes confused and contradictory in his own statements.

Without reaching agreement on a definition of the fundamentals, the discussion usually leads to the question of how best to teach the students, inspire them, and prepare them for their future assignments.

It is important to keep the overall picture of what is to be accomplished in mind in any long range project such as the preparation for an engineering career, and to show the students how their immediate efforts lead to their ultimate goal.

This paper proposes a workable definition of the fundamentals, a method of showing the student the path leading to his ultimate goal, the importance of research, how to give students contact with practice, and the final product which can be obtained.

The Fundamentals

"The Fundamentals" shall be the laws of nature which govern the universe and are, for engineering purposes, often expressed in the form of mathematical equations or laws. It should be realized at this point that our understanding of the fundamentals is based upon our ability to recognize facts correctly and that they have to be revised from time to time as our understanding of these facts becomes more complete. They are not laws in the true sense of the word but rather a formulation of facts as best we see them. When, for convenience, the actual facts are expressed approximately by rather simple expressions, the limitations and restrictions should clearly be stated.

The Path Leading to the Ultimate Goal

Everything worthwhile which has been achieved by an individual, a group, or humanity as a whole was done by striving toward a definite, clearly defined—although sometimes unattainable—goal. All the efforts were directed and coordinated in this one direction and, if persistent, crowned with unbelievable success.

When applying this to the engineering field it is necessary for the teacher to point out to the student the desired goal and every time the student wanders off his course to remind him of the goal and bring him back to the path leading there. This will show the student why his efforts are necessary and the objective to which they lead.

The student has to be made to realize first that he needs the fundamentals. Actually, he gets them in his physics and chemistry courses. The writer himself realized this, not when taking physics, not even after graduation, but when, in his first teaching assignment, he was called upon to teach engineering physics. This

study opened his eyes, and he has since spent much time to help his students understand this.

Then, to be able to work with the fundamentals properly, certain tools are needed which are normally classified under the heading of "Mathematics."

The realization of the above will then show the student what his instructors are trying to do, and he will see how most of his courses during his first two years fit into this pattern.

Since knowledge is of little use to the person who has attained it if he cannot tell others about it, a certain amount of training in composition as well as in speech is desirable if not essential.

While the student is laboring with new concepts and definitions without apparent use for them, he has to be reminded that most of his time during the second half of his college career will be spent in learning the many things he can do with these fundamentals, and how the different fields are controlled by them. Here the range of application of each fundamental concept should be pointed out, giving each course a definite place in the total picture, rather than having a number of disjointed and disconnected courses. The similarity of courses with respect to their fundamental concepts is far greater than most students and many teachers realize. This similarity should be pointed out at every opportunity. For example, the student should be made to realize that he uses the same law of conservation of energy whether they call it Bernoulli's equation in hydraulics, the general energy equation in thermodynamics, or the energy method in dynamics. The same differential equation will solve problems in vibration, electrical circuits and heat transfer. As much as engineering students work with air as a medium, most of them are afraid to tackle mixtures of gases, combustion products, and saturated gases. It usually makes them feel much better when reminded that they have worked with air, and actual gas mixture, without undue difficulty for some time. Similarities of this kind within a course and between courses should always be pointed out.

Through further contact with research, as well as practice, the student's understanding and appreciation of these fundamentals will constantly grow, and his fields of application widen.

The Importance of Research

Up to the last year of the student's career, he has been guided by his teachers in and out of the class room and has been shown many things he can do with the fundamentals he learned earlier. His curiosity has probably given him some cause to wonder what and how much he could do on his own or with a minimum of guidance. Formal course work can never answer these questions, and, unless the student is given the opportunity to prove to himself that he can do things on his own, he will most likely take his first job not knowing his capabilities and afraid to try himself for fear of losing his job. He then leads a not-too-happy existence doing what he is told with little chance for further development.

Therefore in one informal course (and it is called "course" only for want of a better word) a certain project should be chosen by the student and the teacher, and then the student should be allowed to explore and develop it with only a minimum of guidance. The project should be defined in general terms only, so that he then can display his own ingenuity and approach, using the fundamentals which he has learned and has been shown how to use. This special project also demonstrates to the student the difficulty of obtaining accurate measurements; for instance, the temperature of a surface, a quantity which he may use many times in his course work. The student also gets the opportunity to apply accepted methods to his particular problem, and he will learn to appreciate difficulties actually encountered in the engineering field.

Many students have told the writer that they have learned more from one of

these projects than in many courses combined. For the first time they had to draw on all their background instead of on one chapter of a specific book as they did in working the problems at the end of it.

The teacher who engages in research will also be able to give the students something above and beyond the printed page in the book. He can explain and actually show the students difficulties encountered in particular problems and can give them information not yet available in published form.

The Contact with Practice

In many cases due to lack of understanding between the teachers of engineering and the professional engineers, theory is arbitrarily set aside from practice. This is indeed unfortunate, since practice would be lost without theory, and theory would have nothing to stand on without verification through practice.

If the engineering teacher is unable to leave teaching for any extended period to enter industry, he still has ample time and opportunity during the summer and especially through consulting to combine theory with practice. Whenever students come to him for something practical to learn, he can ask them questions which actually came up in his consulting work, and which they can answer with the theory learned thus far. After such examples, the question of theory versus practice does not come up again.

It is very helpful to give letters which are received from industry to the student, asking him to answer them before the instructor answers them himself. On numerous occasions, when agreeable with the companies, students can be taken on consulting trips and while in the background, can see how the theory which they learned in school can be and is applied in actual practice.

The Final Product

Thus, again summarizing the procedures recommended here, it seems of utmost importance to let the student of engineering know what the college has planned for him and why. The teacher has to point out to the student that first he learns the fundamentals and the tools to manipulate them. He is also being trained better to convey his knowledge to others. Then he is shown what he can do with these fundamentals in different fields of engineering, (always stressing the similarity rather than the differences).

Then, before graduating, during his last year he should be urged to apply his ingenuity and resourcefulness to a project of his own with only a minimum of guidance. To complete his training he should be asked to answer actual questions which came up in engineering practice, and, if possible, he should have the opportunity to see how practical problems are handled on the consulting basis.

On the day of graduation the student will know what his college tried to do for him, how well it succeeded, what his personal limitations are, and what is expected of him in the future as a professional engineer.

Polytechnical Instruction in Soviet Secondary Schools of General Education

By STANISLAW KOWNACKI *

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Concurrently with their drive for an ever increasing number of graduates from science and engineering colleges, Soviet planners recently turned their attention to secondary and elementary schools. *Polytechnical Instruction* is the term used to describe the new approach to education at all levels. It involves the introduction of some sort of practical technical training at all the stages of education, from grade school up to college. Like everything else in Soviet Russia, this move has a motivation both in Marxist philosophy and in the practical plans for the industrialization of the country.

From Lenin to the Nineteenth Party Congress

The principles of polytechnical instruction which "does not require teaching everything, but requires teaching the elements of modern industry in general" were first formulated by Lenin in 1920. He recommended the introduction of some limited form of polytechnical instruction even at that early stage of the development of the society which he considered not yet sufficiently mature for a full scale educational reform.

The aims and means of polytechnical instruction were further outlined in the directive of the Central Committee of the All-Union Communist Party dated September 5, 1931, which described it as the education "of universally developed builders of socialism, able to combine theory with practice and to master technology." This was to be achieved through general rather than specialized technical instruction, supplementing rather than replacing existing secondary school curricula. The directive further states that: "Any attempt to separate the polytechnization of schools from the systematic and solid acquisition of learning—physics, chemistry and mathematics in particular—the teaching of which must be based on rigorous and detailed programs, plans, and conducted according to the strictest schedules, represents a gross distortion of the idea of a polytechnic school."

Since 1931 articles of polytechnical instruction appeared from time to time in professional journals, but the idea was not introduced in practice. In October 1952, however, the Nineteenth Party Congress issued a directive for the "immediate application of elements of polytechnical instruction with only slight changes in the program, the textbooks, and the method of presentation" in all the secondary schools in the country. This measure was to coincide with the gradual transition to universal education on the secondary (high school) level first in large towns and industrial centers (1951–1955), and then in the rest of the Soviet Union (1956–1960).

* The following paper is a condensed version of a study prepared for the Center for International Studies at the Massachusetts Institute of Technology when the author was a Research Associate there in the summer of 1954. Facts and opinions expressed in the article are the individual responsibility of the author.

The directive of the Nineteenth Party Congress was first implemented during the academic year 1953/54, after a propaganda campaign using press and broadcasting media to popularize the principles of the reform. These may be summarized as follows:

a) Publishing of special textbooks with a "polytechnical approach";
b) Design and construction of special equipment for schoolrooms (*kabiniety*) and laboratories;
c) Production of numerous training films of polytechnical nature;
d) Publication of articles on the method of teaching industrial processes to the students;
e) Establishment of special training programs to prepare teachers for polytechnical training.

The Actual Meaning of Polytechnical Instruction

Let us now consider the meaning of polytechnical instruction and its effect on normal functioning of the Soviet schools.

Perhaps the best summary of rather lengthy descriptions of the reform appearing in the Party directives and publications of the Soviet Academy of Pedagogical Sciences is provided by a secondary school periodical "Mathematics in Schools," where polytechnical instruction is defined in the following manner: "Education familiarizing (the students) in theory and in practice with all the main branches of productive activities (*proizvodstva*)." Its main purpose is to "give an industrial worker education enabling him to understand the over-all picture of the branch of industry he is working in, and to give him enough general culture (*kultura*) to be sufficiently versatile for a rapid transfer to a different branch."

Polytechnical instruction in its elementary form is to begin as early as possible, suggest Soviet planners. Production of basic commodities of life, principles of farming, application of machinery, and the principles of communication can be outlined in simple stories adjusted to the intelligence levels of small children attending lower grades of elementary schools. This information should be supplemented with practical knowledge acquired through excursions into the neighboring plants, mills, and agricultural establishments.

As the children grow and mature towards the end of their secondary school studies, the load of polytechnical instruction increases, in particular with the introduction of more advanced sciences: biology, physics, and chemistry, and algebra and trigonometry in mathematics, in which the new kind of knowledge is to be constantly applied. A threefold objective is to be attained by the Soviet secondary schools in connection with the implementation of the program:

a) The level of basic theoretical knowledge is to be maintained and even raised;
b) The new kind of knowledge (*znaniye*) of the basic principles of industrial and agricultural production is to be acquired through the extended "polytechnical" curriculum;
c) New abilities (*umieniya*) and skills (*navyki*) are to be developed by the pupils.

According to the Academy of Pedagogical Sciences, the following elements of polytechnical instruction are to be incorporated in the courses of physics, mathematics, and chemistry in the senior grades of secondary schools:

Physics

Knowledge of important applications of physics in technology; principles of mechanical processes (machining) applied to metals; simple machines; basic principles of construction and operation of sources of mechanical energy; scientific principles of the electrification of the country; principles of "automation" and radio communication; transportation technique (principles of construction of

a steam locomotive, electric locomotive, motor car, tractor, steamship, airplane).

Abilities and Skills. Mastering measurement techniques: determination of weight, specific gravity, pressure, velocity, mechanical efficiency, temperature, quantity of heat, voltage and current intensity, brightness and illumination, etc.; mastering some manual skills; mechanical assembly work, electricity and radio modelling.

Mathematics

Knowledge of more important regions of application of mathematics in technology and production; coordinates; elementary functions; parallel projections as a basis for technical drawings; metrical relationships in elementary geometrical figures; derivative as rate of change of a process.

Abilities and Skills. Skillful mental and written computations; ability to approximate figures and to predict approximate results of operations; ability to use tables and references, abacus, logarithmic slide rule; ability to read a formula and to understand the way the magnitude it expresses varies when the components vary in a predetermined manner; ability to translate rapidly points into co-ordinates and vice versa; ability to use square-ruled paper; ability to make use of measuring instruments: the ruler, the tape, the measuring chain, the compass, the calipers, the set-squares, etc.; ability to take measurements in the terrain and to perform required computations, to calculate areas and volumes, to determine real sizes of plots from a plan of a given scale, to break up a plot into required fractions; ability to execute leveling, to draw diagrams; skills in analysis and synthesis of solid bodies; ability to set up and solve equations appropriate to technical and economic problems; ability to balance the credit-debit record sheet, to make an estimate, to keep financial records, books, etc.

Chemistry

Knowledge of the essentials and basic principles of production and application of substances in chemical industry; knowledge of more important branches of chemical industry; the types of raw materials, fuels, chemical fertilizers; typical facilities and supplies of a chemical enterprize.

Abilities and Skills. Handling vessels, instruments, reactors, electric appliances; recognizing substances important in practice and determining their composition; separation and purification of substances; selection of reagents in order to obtain a required substance; preparation of solutions and determination of their concentration; realizing chemical reactions in laboratory conditions.

The Magnitude of the Reform

The magnitude of the task seems to be well understood by the Soviet planners. The program is not to be introduced instantly in its full extent. A limited number of schools is to be affected by it during the current Five-Year Plan (1951–1955), and the remainder is to follow by 1960. In the meantime pressure is put on all concerned, teachers in particular, in order that the "norm" be "fulfilled," or better still, "overfulfilled." True, the teachers get considerable help of both quantitative and qualitative nature from the authorities. The directive of the Nineteenth Party Congress provides for an increase in the number of acceptances into Pedagogical Institutes (Russian Teachers' Colleges) of 45 per cent during the period 1951–55 over that of 1946–50, and considerable help is given to the teachers available at present in the form of the very detailed instructions, directives and recommendations from the authorities, as well as in the form of instructive articles appearing frequently in the specialized school periodicals which in the Soviet Union are of ex-

cellent quality and have a very large circulation.

Yet a teacher's lot is not an enviable one. Many teachers are considerably overworked—working two or even three shifts a day on a permanent basis; many of them are insufficiently qualified for the jobs to which they are assigned (elementary school teachers lecturing in secondary schools, etc.), in which case they are compelled to complete their formal education through evening or correspondence courses. Now a new burden is added: they have to acquire new skills necessary to teach polytechnical subjects, and supervise additional school activities of polytechnical nature, such as students' work in technical and scientific societies, excursions to industrial enterprizes, etc. Here are some guiding principles which, according to the directives of the Academy of Pedagogical Sciences, must be understood and complied with by all the teachers in connection with the reform:

1) The necessity of understanding the regular program in conjunction with polytechnical material; polytechnical material *must not* obscure basic knowledge;

2) Understanding the ideological value of polytechnical material added to the curriculum;

3) The use of polytechnical material so as to clarify material of general courses;

4) The necessity of using local facilities;

5) The necessity of using only that material which can be understood by the students.

There exists at the present moment a very considerable shortage of school buildings and supplies in the Soviet Union, and the additional requirements of the polytechnical program make that shortage even more acute. The directive of the Nineteenth Party Congress stipulates an increase in the construction rate of school buildings of 70 per cent in 1951–55 with respect to the preceding period, and there are vast plans for providing adequate school supplies. In the mean time, however, teachers are expected to show initiative in improvising as much as possible in the way of obtaining equipment from the local sources and furnishing the school workrooms.

There is an interesting institution in the Soviet Union, peculiar to their system, known under the name of "patronage" (*shefstvo*). Almost every organizational unit has its "patron" institution whose purpose is to provide some kind of overseeing of the activities of the "ward" unit, ranging from political control to providing material help. In the case of schools, local industrial enterprises are nominated to be their "patron" organizations, and in many instances they seem to be the only sources supplying the equipment required for polytechnization.

It is interesting to note that the improvization goes often as far as expecting students to provide their own equipment for the laboratory experiments or furnishing the workrooms. No mention is made, however, of the sources from which the equipment is to come in such cases.

Some help is provided by Polytechnical Museums, or Polytechnical Sections in museums of general nature, very numerous in the Soviet Union. It is difficult to see, however, how they can help much since their equipment is usually in short supply also.

As with everything else in the Land of the Soviets, this educational reform must follow the line of Marxist philosophy by being revolutionary in its nature. Its constructive part is to be inseparable from or even preceded by the "liquidation" of an old and alien ideology, represented in this case by "formalism," meaning any abstract ideas in teaching.

A permanent vigil in the fight against "formalism" is being constantly advocated, which in practice amounts to re-

moving from the programs and from the text-books all the problems that have no direct and obvious connection with the requirements of economy or technology. Every theoretical part of the course is to be immediately illustrated with real, practical examples, always stressing requirements of Soviet industry and agriculture and the part played in that particular field by the native (Russian) scientists and inventors.

The Difficulties and the Possibilities

Such are the official policy and the objectives; such is the wishful thinking of the planners. The effects, assuming that the program is eventually fully carried out, may reach a scale unprecedented in the history of education. Is it possible to realize it? Is it not too big and too difficult for the limited capabilities of human nature which can withstand the stress and the strain only up to a certain limit of endurance? These are the questions which we shall now attempt to answer.

There are many and serious difficulties, no doubt. Shortage of teachers; their insufficient qualifications, made more serious by the requirements of the new program; additional effort required of them for numerous extracurricular and out-of-school activities; more factual material required of the students to memorize; lack of additional equipment and accommodation for its use.

At first glance the difficulties appear unsurmountable, and one is tempted to conclude that the program is bound to be a complete or at least a partial failure. One is certainly tempted to draw this conclusion on the basis of observing an educational system appropriate to a Western community. When, however, one considers Soviet schools, their conditions of work and other characteristic features peculiar to their environment, the conclusion becomes less obvious and one hesitates to pronounce the final judgment. There exist several reasons for which we think the reform is more likely to succeed in a totalitarian state than in a Western democracy.

1) We believe that there is high pressure put on both teachers and pupils in connection with the reform: successful ones are rewarded, and the failures castigated in the familiar fashion. There are many ways in which this can be done in a totalitarian state.

2) Both teachers and pupils are accustomed to hard work through long hours, and they know that it is normal for their output to be expected to increase permanently.

3) There is a considerable attractiveness in the program, especially to the young people growing in the atmosphere of hero-worship surrounding an industrial worker, an engineer, and now a scientist. All papers, periodicals, and radio are full of it, and it is no wonder that youngsters believe that inventing new methods of high speed metal cutting or of more efficient excavating are deeds of the highest moral and spiritual value.

In addition to this it appears that Soviet planners are more reasonable in carrying out the reform than they were, for example, in the case of collectivization of farms, which produced such catastrophic results. The educational reform is to be implemented gradually and over a considerable period of time, thus reducing the possibility of its being a failure, especially since no violence will be necessary in this case.

We conclude, therefore, that in spite of all the difficulties, we are inclined to believe that the Soviet Union is on the path of achieving a complete politechnization of secondary schools. It will make very slow progress since the difficulties are many and the obstacles hard to overcome, but if the policy remains unchanged for some time to come, and if the objective is pursued with the same vigor and enterprise with which it was

begun, the polytechnization of secondary schools will prove to be the most revolutionary and by far the most successful contribution in converting the Soviet Union into the leading industrial state, and the final goal set up by its leaders "to overtake and to pass" (*dognat' i pieriegnat'*) the West apparently will have been achieved.

Final Implications and Conclusions

And now the question arises as to whether this reform is the right path for the development of any modern society, and is it to be followed by all those who do not want to be left behind?

Three distinct aspects can be discerned in the complexity of the picture: first, a short range objective of building a highly industrialized society and state; second, an attempt to create a universally developed man, combining theoretical knowledge with practical skills; and third, achieving this through a perfect balance between theory and practice in the field of education, expressed so eloquently in the exposition of "formalism" and in the necessity to fight against it.

There seems to be no doubt that to the first objective, a rapid industrialization of the country, polytechnical instruction is a positive contribution. The fact is being recognized outside of the U.S.S.R., and when one studies directives and recommendations of various Boards of Education in the United States, one finds references to "elements of polytechnization" often outdoing those appearing in the Soviet literature. Polytechnization is, at least for the time being, of a greater urgency in Russia, since it is one of the very helpful factors in filling the still existing gap between the laborer and the engineer which, in most Western countries with an older industrial tradition, has never existed.

The second objective inherent in the idea of polytechnization is the creation of a man of "universal culture" necessary, according to the prophets of Marxism and Leninism, for the development of a truly communist society. We would be inclined to agree, perhaps, that a nation composed of Leonardo da Vincis is an advantage with respect to the one composed of average men. The question arises, however, whether it is possible even to approach such an ideal, and whether it would suit the majority of the persons concerned?

There is a school of thought according to which maximum output is obtained from any undertaking if the objective of it is set at an unattainable level. From this point of view asking too much of an average Soviet citizen does make sense. If he is compelled to strive to become a manifold genius, he may eventually attain a higher level of professional development than he would have done without this special inducement, thus becoming a more valuable asset to the state. On the other hand a vast majority of people have no such far-reaching ambitions, and it is doubtful whether they would display too much enthusiasm in collaborating with the idea. Furthermore, at the present stage of development of industry and argiculture and the associated division of labor, there are still many jobs requiring people with limited ambitions and capabilities. Here Leonardo da Vincis would be out of place and would become an additional problem. Of course, with further progress in different fields the situation will change, but until this happens the aims of polytechnical instruction with regard to creating universally developed members of society may be considered premature.

Third and last: the basis of polytechnical instruction is to be a perfect balance, a perfect harmony between theory and practice. No theory detached from practical application is to be entertained, no abstract, "formalistic" ideas are to be tolerated.

At first glance this seems to be a very reasonable scheme, especially in Russia and for the Russians who were famous in the pre-Leninist era for their out-of-this-world ideas. These are now to make room for practical plans leading towards real and definite objectives.

When it comes to expanding highway or canal systems, designing new types of computing machines, or even developing multi-dimensional geometries for specific purposes, the scheme will work beautifully and efficiently. But for how long will it last? How long will it be before the existing patterns of scientific thinking are exhausted and the progress is slowed down or stopped? Is it possible to kill "formalism"—the abstract, the detached thinking—without killing progress itself so often emanating from this kind of thought?

It is our contention that in the long run the abstract is just as necessary as the immediate reality. And not only for its own sake, but for the sake of that very reality of which it appears to be a most striking contradiction. After all, where would the electrical or aeronautical engineering sciences be today if Cauchy had been forbidden to develop his functions of complex variable, based on the concept of imaginary numbers, the very name of which implies things alien to practicability? Where would modern technology be today without inventions of Faraday, "as useless as a newborn baby," or theorems of Taylor unrecognized even by his fellow-mathematicians for a long time? And where would we be without "formalism" of Euler or Lobachevsky, who is now treated as if he were a "Hero of the Soviet Union"—a century after his death—in spite of his most abstract ideas, certainly deviating from the straight and narrow path of Marxist realism?

So it appears to us that a free enquiry of inquisitive minds, unrestrained and unrestricted, can never be replaced by any planned development no matter how perfect. Let us not be ashamed to look for answers to any question, no matter how useless or absurd it may seem. With this we may reasonably hope to remain in the future, just as we have been in the past, ahead of the others, without fear of being permanently passed or overtaken.

On Teaching Creative Engineering*

By C. D. FULTON

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"The only proper study of mankind is man"
—Pope

It is highly anomalous that American engineering educators have done so much to discourage ingenuity in young men striving to be Ingenious Ones. We have tried to make machines of our students and to convince them that thinking is not good engineering. We have taught them to seek every answer in books and rules, to distrust their own minds for any purpose except mechanical sorting, and to be ashamed of an idea that they could not document. Fortunately, we have not succeeded; our graduates have adapted themselves to the very different real world of practice and have put their imaginations to work as their Creator intended.

How did we fall into this dismal error? Some say that out of sheer laziness we took the easy and secure way to teach, but they overlook the fact that sincere and ambitious teachers were equally dedicated to that way. No, we believed in it. Perhaps we inherited it from the old grammarians who thought to make poets through spelling and punctuation. Perhaps we caught it from the scientists. We may have invented it ourselves. In the final analysis, however, we believed in it because we came to worship sacred-cow science. Our dream of perfect engineering was a digital computer, a shipload of punched tapes, and no human beings to spoil the results.

The physicists had the same trouble. In the twenties, they began to believe that the universe could be reduced to protons and electrons hooked up by Einstein's equations. The answer to anything was supposed to be in the formulas if one took long enough to grind it out according to the rules. But today, a chastened physics profession is valiantly trying to recapture the many strange creatures that have flown out of its Pandora's box, and they suspect that even if they manage to clamp the lid shut, it will pop open on another day.

The sacred cow is dead and its reeking carcass should be hauled out of the engineering classroom.

Progress in Engineering Education

We are in the midst of genuine forward steps in engineering education. Perhaps they began with the Wickenden report with its call for a cessation of divisions of curricula and its insistence upon lifelong education. Next came the strengthening of the humanities in the curriculum and then World War II with its countless stimuli. Today there are more signs of progress: the rise of engineering research; new evaluation studies by this Society, with their call for emphasis on the engineering sciences; new studies and the beginnings of instruction and writings on the art of en-

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gineering teaching; and now the return of creativity from exile.

The engineering sciences which we are now called upon to emphasize must not be like the old scared-cow sciences. They must be dynamic. We must teach them as flexible tools which an engineer can employ when they are useful, not as millstones about his neck. The engineer must be educated for change not impressed from without but springing from within himself.

Creative engineering is being rescued from the pedagogical dungeon by pressures from all sides even including engineering sales. The degree to which this emancipation has already progressed is indicated by the reversal in our attitude toward Edison who, twenty years ago, was generally regarded with a mixture of envy and suspicion but today is being recognized as one of the greatest of our profession. But creative engineering is still going to have a difficult time making its way into our classrooms because we are so steeped in our set-rule methods that we shall not only be reluctant to give up their comfortable ways but find it hard to develop new ones for lack of knowledge. There is virtually no documentation on creative engineering and it is enmeshed in psychology. As a result we shall find ourselves trying to catch a ball in the sun with a glove that we don't know how to use. It may well take us a generation to learn how to teach creative engineering.

In spite of these difficulties, if we will maintain the progressive pace now evident in engineering education, we may yet reach the point where we can begin to lead the profession instead of following two decades behind it. Perhaps we shall also learn how to teach engineering with an efficiency of 15 per cent instead of 10 per cent.

Convention and Creativity

A study could be made of the operations of engineering—such acts as setting up an equation, fitting parts together in a sketch, predicting whether a quantity increases or decreases, or deducing the mechanism of a process. While there are surely many possible ways of categorizing the operations, it will be sufficient for present purposes to recognize only two categories, the conventional and the creative. In another age these terms might not make sense.

Conventional engineering, which we have been teaching, is a network of formulas, data, rules, and static science bound into a firm discipline. It demands rationality, order, repetition, patience, caution, thoroughness, and scholarship. The more one adheres to a predetermined step-by-step process, the better conventional engineering does he do and the more inevitable is the result. This kind of engineering is a machine-like process and machines are beginning to be employed to do some of it. It is indeed a considerable part of engineering and we have done a good job of teaching it.

Creative engineering, on the other hand, operates on emotion, imagination, chance, boldness, rebellion, abandon, flight of fancy, and every other quality which distinguishes the live human being from the inanimate machine. What we mean by creative engineering is suggested by naming a few of its great practitioners: Watt, Faraday, Kelvin, Otto, Diesel, Edison, the Wright Brothers, Marconi, Ford, de Forest, Whittle, and Shockley.

The creative act is one of the least understood of human adventures. For that reason we look with awe upon it; we feel an elation; it seems that a divine spark strikes within us and for a moment we transcend ordinary existence. Even if we had to proceed with no more knowledge of the creative act than we have now, however, we could do a far better job of teaching creative engineering than we have done.

But it would be the ultimate pessimism to believe that creative thinking must be forever unknowable, for history abounds

with examples of how light has been cast on mysterious phenomena when they have been studied conscientiously. If we will devote ourselves to the task, we shall surely be able to strip away some of the mystery of the creative process and thereby increase our power over it. It is certainly not the mere play of chance; it must be the end result of a series of experiences, stimuli, and mental processes which can be identified and analyzed, and then effectively cultivated. In this research we shall have to depend heavily upon the psychologists. Let no one fear that the dignity of the human spirit will be diminished: as we learn more about the human being, our awe increases with our power.

Enlightenment of this kind will give us tools for teaching creative engineering in a straightforward manner. Instead of providing suitable soil and simply hoping that plants will spring up in it, we shall be able to sow the seed and cultivate the plants. Inasmuch as we needed this information yesterday, we had better get started.

The Hats

If creative thinking were for the few, this discussion might end here. It is true that some engineers are born with more creative ability than others and that some engineering operations require more creativity than others, but the plain fact is that every engineer—researcher, designer, tester, manager, salesman, and all—faces situations demanding creative thought in every move he makes. He must conceive a series of little inventions of scope, interpretation, assumption, emphasis, choice, procedure, and evaluation. The warp of these inventions combined with the woof of conventional knowledge makes the cloth of engineering.

Or we might draw another analogy. Conventional engineering is a thin network of roads across the world of engineering. The roads are sometimes very good like Newton's laws, and sometimes they are merely trails like convective heat transfer. As long as one stays on the roads, he only goes where someone else has gone although he may improve the roads. To go anywhere else he must hike off into the wilderness without signs or comforts. Sometimes great discoveries lie a short distance from the roads; sometimes an exhausting exploration produces nothing.

Engineering is a succession of conventional and creative operations and the engineer must be able to change back and forth from the conventional to the creative hats as he moves through the various stages of a problem. The degree to which one of the hats sticks on his head when it should come off is a pretty good measure of what mistakes in judgment he will make, while the rapidity with which he can change hats is a fair measure of his speed and versatility. There are men who cannot take their own analytical results and apply them sensibly to the physical situation at hand. The conventional hat is stuck on their heads. There are also men who, while excellent experimentalists, cannot integrate their work into the stream of knowledge. The creative hat is stuck on their heads.

I experienced a costly example of the stuck conventional hat when working on a refrigerator for ultra low temperatures in 1949. By making calculations based on extrapolated data, I proved that a certain part should be $\frac{1}{8}$ inch in diameter. A year and many exhausting experiments later, that part was still conducting 500 times too much heat and I ended the project discouraged, having tried one scheme after another to cure the trouble. Still another year later, I was mulling over the mystery for the n^{th} time when it dawned on me that if the part was conducting 500 times too much heat, what I ought to have done was forget calculations, theory, and all and make it 500 times smaller. Sure enough, a few months later came new measure-

ments from England showing that the heat conductivity of solid helium at ½ degree Kelvin is 500 times greater than had been supposed in 1949. How easy it would have been to save my project and beat the Englishmen to the draw if I had only taken off the conventional hat and put on the creative one at the right time!

If all this is so, we ought to teach it systematically in the classroom. We ought not to pretend that the conventional hat is the respectable one and that the creative hat shows up a fellow as a scientific tramp. Nor should we pretend that we are wearing the conventional hat all the time when we are actually switching hats. Fortunately, students tend to do as we do more than as we say do, but if we will both do and say the same thing, will it not produce better results?

Another weakness of our old methods is that most of our classroom problems are artificially contrived with half the creative thinking already done. How poorly our students do when confronted with an entire machine interacting with its environment and asked to find the problem, identify the important parameters, reduce the situation to its essentials, and get a theory! How poorly they integrate the pills of knowledge that we call courses!

We should not only teach them how to change hats but also give them material calling for plenty of practice in that art.

History, the Untapped Resource

By largely ignoring its history, the engineering profession has passed up a rich source of inspiration and wisdom. All that most of us know is a few names and dates and a handful of anecdotes. We must learn our history. Then we must teach it.

But lifeless history would be useless. To catalog inventions is an abominable way to teach history but it has been tried on occasion. To list scientific discoveries and principles is abominable but that has been tried also. History can be magnificent if taught in terms of the flesh and blood human beings who made it—in terms of their hopes, fears, struggles, mistakes, and triumphs. We should teach it as an integral part of every course.

To expound the First Law of Thermodynamics without telling about the Caloric Theory is a crime. To say that Diesel developed the most efficient of engines without telling how it would not even propel itself for three years is a crime. To discover the Wright Brothers at Kitty Hawk just when their contraption is ready to fly without telling how they had come to that great moment is a crime. To say that Midgley discovered tetraethyl lead to be a knock inhibitor without mentioning that he had first tried 600 other substances is a crime. Our whole scheme of presenting a finished idea to our students as if it had sprung full blown from the head of Zeus is incredibly bad.

We ought to teach a natural law or engineering development as a prize of war captured by the human race in a struggle in which Newton or Ericsson or whoever it was was the victorious general. We should tell about the losing side—who they were, what they advocated, and why they lost. By teaching how we came to be where we are, we will teach how to extrapolate into the future. Such teaching will be a powerful way to build creative engineering.

History will bring other advantages beyond the scope of this paper but I cannot refrain from mentioning two of them. The first is that the historical method is by far the best way of teaching a difficult concept, like entropy for example. Since nobody ever taught me how Clausius actually invented entropy, I am using a little fable temporarily. I have no doubt that the actual story will be better than my fable, which begins, "Clausius was strolling down Unter den Linden one Sunday afternoon in 1847

when he said to himself, 'Mein Gott, it giffs isotermal und isopiestic und isovolumetric prozesses, but vot in Himmel iss konstant in ein reversible und adiabatische expansion?'"

The second advantage is the enormous cultural benefit of integrating engineering history into the minds of the engineering profession. It is partly because of our ignorance of history that we appear unlettered and unpolished to many people. It is there that we could find some of the continuity, cohesion, poise, judgment, and insight that we sorely lack.

Unfortunately, this reform cannot be carried out in the near future because of the appalling vacuum in adequate historical works on engineering. Most of the existing ones are written by laymen or for laymen and fail to convey the inside story of the scientific and intellectual experiences of the protagonists. Nor is there enough engineering history in the textbooks to fill a thimble. Source material is hard to find and we have let many of our historical streams dry up. There is therefore the tremendous preliminary job of getting this material into useful form and disseminating it. This will require years of work by literate engineers well attuned to human passions and willing to do a lot of hard digging. Here is another piece of research that we needed yesterday.

Creativity in Textbooks

The general deficiencies now discernible in our textbooks cannot be laid to the authors. Textbooks are an organ which cannot progress faster than the educational animal; indeed, they lag behind because they must be built on pedagogical certainties. Publishers are conservative. So, unfortunately, are professors when they choose books for the next term.

Whatever has been wrong with engineering teaching has therefore been even more wrong with the textbooks. Most of them have been written entirely in the conventional engineering mode and have catered to sacred-cow science. They have developed the student's power of digestion, not his power of finding food. Principles have been laid down with Olympian assurance in defiance of experience which guarantees that within the lifetime of the student those principles will be greatly changed. There has been virtually no history: everything has sprung out of thin air. Creativity has starved to death.

There are, however, some additional problems particularly relevant to textbooks. One of the reasons that many of them have been little more than catalogs is the well known pressure to include every development in the technological field being written on. The result is that the author who has tried to include even a representative sample has been painfully squeezed. He has become frantic to meet the requirement of coverage and has had no room left for such luxuries as history, exploratory discussion, philosophy, or self-discovery —in short, for creativity. Today, the luxuries begin to look more and more like essentials, and coverage more and more like a luxury. The textbook of the future will use applications only as means of teaching basic science and not as ends in themselves. In this way the pressure to include this or that development will disappear; the real pressure will be to include the science and to present it in a creative manner.

A more subtle problem is that most textbooks have been tacit combinations of educational and reference works and have consequently failed to be either. The requirements of the two are incompatible. Is the student who is trying to grasp the First Law of Thermodynamics enlightened by an array of assumptions, special cases, and equations? No, but the engineer who is trying to find out how to write the centrifugal work term in the First Law for gas flowing through a helicopter blade is not helped by a dis-

cussion of Joule's experiments. The time is ripe to design educational works solely for educational purposes. This too will make room for creativity. Fortunately, our technology is becoming big enough to support two systems of books.

Creativity also suffers from an uninspired style of writing and from dullness of composition and arrangement. Literary artistry is just as much needed in an engineering textbook as it is in a novel.

Enlightened authors are already putting some of these reforms into practice. Too much cannot be expected too soon, for the way to write the textbook of the future is certainly not yet known. Experiments will be necessary and some failures are bound to occur. The rate of progress will depend to a very great extent on how much support the teaching profession gives improved textbooks as they appear. Let it never be said by a publisher that he offered us the kind of textbook that we say we need and we would not use it.

The Next Frontier

In instituting all these improvements, we shall have our hands full for a long time. But what will be the next frontier? Shall we wait until we are again behind the times to begin the reforms that will be due a generation hence? No, let us move into a continuous research program that will keep us ahead of the profession as we ought to be.

If we call the next unknown quantity X, perhaps we can derive it by extrapolating the change now in progress in engineering education—the change from applications to sciences or from convention to creativity. Then we would write

$$\text{Applications}:\ \text{Sciences} = \text{Sciences}:\ X$$

or

$$\text{Convention}:\ \text{Creativity} = \text{Creativity}:\ X$$

We are ascending the scale from the specific to the general or from the effect to the cause. Then X, the next frontier, must be a deeper understanding of the principles underlying all science and creativity.

What will be the nature of this understanding? Let us suppose for the sake of discussion that the rise of science during the past three centuries was caused by the advent of three new ideas which were added to the ancient idea of inductive reasoning. The first new idea was the overthrow of the hyper-Aristotelian doctrine that reasoning is more to be trusted than experiment, in favor of the counter-doctrine that experiment is indispensable. This meant that you ought to do a lot of tinkering and that if you saw a light stone and a heavy stone fall at the same rate you ought to leave off believing that they fall at different rates.

The second idea was that you ought to measure everything and express it in numbers. This also meant that you ought to develop instruments.

The third idea was the new mathematics crowned by the calculus.

Assuming all this, we have a sort of recipe that says to put these four ingredients into the human being and you will get the kind of science we have had. It is time to probe beneath this empiricism. We know very little about the psychological reactions in the mixing bowl. We do not know how to vary the recipe to get other and perhaps better combinations.

Or perhaps the next frontier will lie in a slightly different direction suggested by Percy Bridgman's observations on the Paper and Pencil Operation.* He points out that in solving a certain type of problem we go through four steps in which we first explore and define the problem, then write down the laws that we need to solve it, then go into an opium fog where we turn the mathematical crank according to established rules (the Paper and Pencil Operation,

* P. W. Bridgman, *The Nature of Thermodynamics*, Harvard University Press, 1941.

divorced from physical reality), and finally emerge with an answer which must be interpreted back into the physical world. Bridgman has thus done an operations research into a small part of science. Perhaps studies of this kind are what we shall need.

The problem may be hazy but we must not be so shortsighted as to discount it. If the blacksmith of 1820 had said that there was no need to know more about the heat treating and alloying of steel, he would have been short-sighted. And if we artisans of engineering today say that the science of engineering thought and creation need not be explored, then we are short-sighted and we shall be left standing on the platform when the train pulls out.

We shall have to pay more attention to the psychologists. Our present coolness toward them is attributable not so much to their difficulties, as we claim, as to our incomprehension of a field foreign to our way of thinking but increasingly impingent upon our needs.

Whatever answer lies ahead, it will improve our teaching. Then we shall not have to teach nine, or fifteen, or thirty basic engineering sciences as separate disciplines, but we shall be able to teach a single discipline of which these sciences are applications! Then the efficiency of engineering education may rise from 15 per cent to 20 per cent. The solution to the increasing complexity of the age will be, as always, to consolidate on new and broader philosophical levels.

Teachers Above All

Methodology and reform are useful but the indispensable ingredient of education will always be the teacher, upon whose genius and devotion everything depends. Of all the qualities spoiled by a dull teacher, creativity is hardest hit. We need better men in engineering education; we need the very best that the profession can muster.

It is one of the scandals of engineering education that most engineering teachers are thrown into teaching without any formal preparation for it. Only because we have much company in other college professors do we get by with this laxity. The American Society for Engineering Education has made a good start toward attacking this problem; let us help it redouble its efforts. Let us write books on engineering teaching and offer a course on it in every engineering graduate school.

If we will develop our teachers as we should, we can win the reputation of being one of the most enlightened groups in college education.

Conclusions

1. If engineering education will continue to reform, it can eventually begin to lead the engineering profession.

2. Creativity, long neglected and discouraged in engineering education, is beginning to receive attention. Educators should uproot sacred-cow methods and develop methods for teaching creative engineering. This will be difficult and will take time. Research on the creative process should be pressed.

3. All engineering is a series of creative and conventional operations and engineers should be able to change rapidly back and forth from the creative to the conventional hats. This procedure should be taught rationally. Creative thinking should not be distilled out of classroom problems.

4. Engineering history should be dug out by researchers and put into usable form. It should be taught as an integral part of every course, not as a course by itself. It should not be a dead chronology, but an intimate account of the experiences of real men with their difficulties, mistakes, and triumphs. Concepts and principles should be introduced by the historical method.

5. Textbooks should be redesigned to inculcate creativity. They should teach engineering sciences using applications

as means and not ends. Coverage of developments should be sacrificed in favor of history, philosophy, self-discovery, style, and composition. Educational textbooks should be distinct from reference books, research papers, or other forms of writing.

6. Research should be done in the science of engineering thought and discovery. This research should utilize psychology to the fullest extent. The results will permit further improvements in engineering education.

7. Engineering teachers should be the best men that the profession can muster. Their training should be earnestly developed through every available means including courses and books.

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The Engineering School of Tomorrow

By MILTON O. SCHMIDT

Professor of Civil Engineering, University of Illinois

The engineering school of tomorrow will be the hallmark of those professional attitudes, ethical principles, and intellectual attainments which are seriously needed today by America's engineers as they seek unity among themselves and a better measure of recognition from their fellow citizens. The engineering school of tomorrow mindful of the great charge entrusted to it—to educate rather than to train—will break sharply from the mold in which engineering institutions have been cast in this country for the past 100 years. It will set itself resolutely to the task of securing dignified respect for engineering as it educates young men to fulfill the highest concepts of ethical conduct, technological achievement, and social understanding.

The forerunners of the engineering school of tomorrow may be the five-year curricula institutions who are offering a broader educational base for professional practice. A lesson could be taken from the programs of the dental and medical schools who have insisted upon pre-professional training for several decades. May it not be refreshing that engineering students be introduced to the disciplines and values of letters and arts. May it not be wise that they demonstrate higher proficiencies in oral and written expression before they enter a school designed for young men who have the mental and moral fiber needed to lend strength to a profession which is old in years but may not yet have come of age.

The emergence of the engineering school of tomorrow from the school of today will not be rapid or assured. Its metamorphosis will depend largely upon the quality of its staff, the careful choice of students, and upon the organization and administration of curricula. The task of redefining the structure of American engineering education will demand the best efforts of bold and imaginative administration with principles such as the following forming a guiding framework:

1. Professional rank and title will be guarded more zealously. Academic title will not be prostituted by the inadequacy of budget. Mediocre staff will not be recruited with the allurement of title when funds are insufficient to employ competent personnel. It will not be assumed that a good engineer is also a good teacher. Hence, the situation of a former downtown engineering assistant suddenly finding himself invested with the title of professor will not be permitted.

2. Schools will be on guard to prevent the appointment of too many of their own graduates unless they have been elsewhere since graduation and have been leavened by contact with the practice of engineering and by teaching experience at other schools. To neglect these precautions will be to invite not merely academic inbreeding but intellectual incest.

3. Increasing emphasis will be given to the appointment of professors of wide general intellectual interests as opposed to the engineering recluse who ordinarily lacks the perspective or the desire for effective exploration of new educational channels or may be incapable of generating a desire for learning.

The better professor will aid his students to appraise things at their true values, to seek out the truth on all issues

and to act as valiantly for the unpopular beliefs as those which are more palatable but no more sound. He will urge them to view objectively the special interest groups, the trade unionists no less than the P. E.'s, and to beware of the false prophets.

4. The teaching loads will give opportunity for continued individual study, reflection, and self-improvement, for the true engineering professor must embody the principle of continuing adult education he seeks to preach in his classes. For him there can be no release from the constant demand to know more about men and machines. This insatiable curiosity to learn all interrelations is a true index of the learned one—the professor. Woe to the school that casts the magic mantle of tenure over the soft shoulders of those who delight in the academic life because of the opportunity it affords to spend the generous hours away from the classroom in the prosaic pursuits of domesticity, in hobbying, following the telecasts, and other intellectual-numbing activities.

5. The tendency of the young instructor to engage in outside work will be viewed with concern if such experience is routine and of a production nature, and the teacher uses the advantages of a salaried position to compete with other engineers. Good teaching is considered a full-time enterprise which can be best strengthened and steeped in engineering practice by gaining creditable experience during leaves of absence with reputable engineering organizations.

6. The attainment of intellectual capacity and the development of an ethical sense will gain ascendancy over the importance of engineering procedures and practices since the engineering school of tomorrow will consider itself the standard bearer of the engineering profession and the co-guardian with the technical societies of its integrity.

Students

The engineering school of tomorrow will give vastly more consideration to the selection of its students. It will realize that their quality is much more important than their numbers. It will effect liason with the technical institutes so that capable technicians can be trained from among those not capable of surviving the rigors of the professional engineering school.

It will launch extensive programs of aptitude testing to determine the capabilities of each applicant for admission. In its study of candidates the school will spare no efforts to portray the nature and extent of engineering employment—its shortcomings and its triumphs—for more than anything else must there exist in the make-up of the prospective student a great desire to become an engineer.

Administration

The engineering school of tomorrow will break boldly with tradition on matters of organization and administration of its curricula. It will recognize the essentially fluid character of academic programs of study and acknowledge they are constantly in transition.

Its administration will be quick to detect sycophancy in its staff. It will be able to distinguish between ordinary authorship that may break into print and quality scholarship; between the scurry and disorder of undistinguished committee work and the high quality of unrecognized student counselling; between departmental clerking and virile instruction. It will not be intimidated by cries of academic imperialism and taunted into submission or retreat when the issues of the day and the responsibilities of administration call for prompt and decisive exercise of authority to accomplish action. It will recognize it is better to deliver on time while occasionally making mistakes than to breed the air of uncertainty and indecision which is engendered by endless delays and habitual vacillation in executing policy.

Finally, the distinguishing feature of a university education should be a widening and deepening of intellectual capacity and

power. The engineering school of the future, usually attached to a university, will not tolerate mediocrity in any area. It will strive to give its graduates a sound understanding of fundamentals and enrich and strengthen their intellectual resources. By accomplishing this it will serve notice to the world that engineering and engineers have finally come of age. Not until such time as the engineering school of today becomes the engineering school of tomorrow will the engineering profession be able to dissolve the miasma of uncertainty, ordinary stature, and lack of professional recognition that envelop engineers today.

The Integration of Humanities into an Engineering Program

By J. STUART JOHNSON

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A great deal has been said, and printed, on the subject of the need for liberalizing an engineering education. Surveys have been made by engineers and liberal arts people alike, in an effort to determine the desirability of inclusion of material in the social-humanistic areas in an engineering curriculum, and to determine the amount and type and degree of coverage of such material.

I would like to submit that any number of credit hours will not accomplish the desired purpose unless the necessary stimulation is provided. I would like to submit further that a long sequence of courses in any one small area of the entire field will not necessarily provide that stimulation.

A few years past, a magic number of 20% was proposed as the minimum amount of nontechnical material which should be included in an engineering undergraduate curriculum. Many schools attempted to adjust curricula to fit this magic number. A few took the term "minimum" in its literal sense, and held strictly to this amount. Others went far beyond it. Still others, however, argued that the amount of time available for engineering work was not sufficient, and did not reach the 20% figure.

I believe that it has been recognized by all concerned, recently, that the specification was not based on firm foundation. It is not argued that engineering graduates should not be acquainted with philosophy, psychology, history, and the various subjects generally considered in the arts and sciences area. Nor, I believe, is it a matter of disagreement that persons trained in the fields of history and sociology should present this material to the engineering student. My thesis concerns merely the manner in which this material is presented, together with the intensity of presentation in any one area.

Three Stages

I would contend that there are three stages through which the liberalizing processes go. Briefly, these would be the introduction to the subject by the specialist, the continued application of the material as a part of a technical course, and third, the self-development of the student after graduation. I would contend that an engineering program which, exclusive of English composition, grammar, and speech, includes one course per semester in each of several areas of the social studies and humanities, would serve as the training field corresponding to the first stage. I would not propose, however, that a course in history in the junior year be taught as what might be termed an introductory course in history, or a more detailed course in history covering a specific period of time, such as might be taught to an arts and sciences student, who conceivably would take more courses in the field. I would suggest that the single course be taught with a view to identifying the impact of history and historical events on the student's own profession. Similarly, I would feel that a course in government, rather than representing a detailed study of governmental

structure, be slanted toward impressing the student with the effect of matters pertaining to governmental organization and action on the engineering profession.

In other words, a fundamental course in each of several areas in which the subject is closely identified to the student's own profession, in such a way as to show him his professional relationship with these various areas, would, I believe, serve as a strong stimulus.

The second stage of the student's training in the so-called social-humanistic stem would be obtained in the actual professional courses themselves. There is no reason why the engineering instructor cannot, and should not, continue to identify the professional field in its relation to history, government, economics, and similar areas considered as nontechnical. This, of course, would require an appreciation on the part of engineering faculty members of the importance of these areas as well as an ability to link the two things together.

If the student had passed through these two stages in the proper manner, I feel reasonably confident that he would have been imbued with the belief that his profession is not isolated, but is an important part of a much larger field. Having gained the stimulation through these two stages, he should not only be capable of, but desirous of, continuing to establish the further relationship after graduation.

It is believed that the above procedure would result in a broader coverage of nontechnical topics in a relatively conservative amount of time, insofar as the percentage of time devoted from the engineering program is concerned. It is also believed that the approach designed to relate the nontechnical areas to the student's professional activity would provide a stimulation for further study in the area. It is still further believed that the engineering program itself might take on more value as a result of the relationship which would be established between the two areas.

Candid Comments

By H. A. MARCOUX

Professor of Mechanical Engineering, University of Arizona

In the college of engineering our freshman students are confronted with a problem which must be common to every university student. Sooner or later they realize that since their classroom work will become increasingly technical and demanding, the burden of obtaining a broader and more rounded education must, of necessity, be carried by the individual. There is a definite advantage in having this situation become clear-cut and obvious early in one's university career. Basically, it confronts every student whose pattern of interests and habits is in the formative stage—and some who have begun to question the established routine of their college life.

The well educated man is not merely technically proficient in his chosen field, but, above all, possesses intellectual and social maturity. This distant goal cannot be attained automatically by passive attendance, however frequent, at the many and varied activities which university life encompasses. Exposure to the fields of literature, art, music, history, philosophy, and science is, of course, a prerequisite to an intelligent and respectful appreciation of the facets which comprise the background of a well-rounded education. But education is an active process. An individual must experience actual reactions to these outside stimuli. If the reaction is one of satisfaction, of deepening interest and awareness, a process of intellectual growth is set up. This can only be accomplished by a deliberate effort on the part of the student to develop within himself a state of readiness and receptivity which will transcend that required for classroom routine.

The degree of accomplishment in any particular field is selective—and, compared to a specialist, very limited. However, there are rich rewards for the smallest efforts toward broadening one's horizons. One can find a greater sense of personal fulfillment, a truer concept of one's effectiveness and status in our society, and a broader understanding of human relations. If his development is genuine and complete, a habit pattern will be set up which will enable him to continue throughout his life to grow and develop—to choose the more stimulating book, appreciate the finer music, and be more tolerant toward his fellow men.

Industry Views the Engineering Graduate and His Curriculum

By WILLIAM K. LEBOLD

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Purpose

When the national committee on the "Evaluation of Engineering Education" was organized by the American Society for Engineering Education, each engineering school was asked to form a study committee to consider the overall phases of engineering education. At Purdue University a Curriculum Study Committee was appointed to consider the general problem of determining the educational requirements of graduate engineers "competent to serve the needs of the engineering profession over the next quarter century." Purdue's committee was aware of the close relationship existing between the faculty and those leaders in industry responsible for the selection, placement, and development of engineers. In view of this relationship, the committee requested industry's leaders to provide information concerning the present supply and future demand for engineers trained to various educational levels, and in addition, to give their opinions regarding the content and duration of engineering curricula.

Procedure

A questionnaire was prepared to meet a twofold purpose:

1) To determine the distribution of engineers among the various job categories in which engineers are generally employed and to determine what difference, if any, the level of degree makes, and
2) To determine the attitudes of industrial leaders in regard to engineering curricula.

The selection of companies and the individual within each company was important. The following criteria was used:

1) From a list of 800–1000 companies who send representatives to interview potential engineering graduates, typical companies were selected.
2) From the companies chosen, a further selection was made of those individuals in industry which committee members felt were in a position to supply reliable answers.

One of the assumptions underlying the questionnaire is that engineers can be classed into one of three categories defined as follows:

A. "Those who deal primarily with new technical ideas or products. This would include research, development, design, etc.," hereafter in this report referred to as *New Developments.*

B. "Those whose primary function is the operation of existing facilities or the execution of existing plans or designs. This would include production, construction, operation, service, etc.," hereafter referred to as *Operations.*

C. "Those who deal principally with the human element in technology. This would include production, supervision, sales, personnel work, etc.," hereafter referred to as *Human Relations.*

About 170 companies that employ engineering degree personnel were sent questionnaires together with an explanatory letter. In general, the questionnaire was addressed to the person in charge of engineering college recruitment. Usable ques-

tionnaires were received from 85 companies or approximately 50% of the total. The questionnaire was for the most part filled out by the addressed person, although he occasionally referred it to one or more persons in his respective organization.

The companies responding included those in the aircraft, chemical, food, electrical, heavy machinery, and metal trade industries as well as railroads, utilities, and a world-wide construction firm.

Results

The questions submitted to industry's leaders are given in Appendix A together with summary tables. The results have been grouped into two major divisions:

1) A classification of employees with engineering degrees—Questions No. 1 to 6.
2) Engineering curricula opinions of industrial leaders—Questions No. 7 to 12.

Engineering Degrees and Job Categories:

The first question in the questionnaire asked for the number of engineering degree employees in each of the participating companies. Question No. 1 reads as follows:

Approximately how many persons with engineering degrees does your firm now employ?

The questionnaire came from companies employing anywhere from 13,375 to 3 engineering degree persons. The median number of engineering degree persons employed was 277 among the 85 responding companies. (See No. 1, Appendix A for a Frequency Distribution.)

In view of the job categories previously defined, *New Developments, Operations,* and *Human Relations,* the questionnaire asked:

"2 *How many of your employees having engineering degrees can be classified in each of the categories?*"

The complete results are tabulated in No. 2, Appendix A. A breakdown of 1953 engineering degree employees is as follows:

Those having Bachelor's degrees accounted for:

83.8% of those in New Developments
95.9% of those in Operations
93.3% of those in Human Relations
or 90.1% of those in all three categories.

Those having Master's degrees accounted for:

13.0% of those in New Developments
3.9% of those in Operations
6.4% of those in Human Relations
or 8.4% of those in all three categories.

Those having Doctor's degrees accounted for:

3.2% of those in New Developments
.2% of those in Operations
.3% of those in Human Relations
or 1.5% of those in all three categories.

The overall breakdown indicates that at the time of the survey the responding companies had engineering degree employees classified as follows:

41.9% were active in New Developments
30.4% were active in Operations
and 27.7% were active in Human Relations.

The responding companies employed a total of 75,565 engineers, a fairly large sample of the national engineering degree population (estimated to be about 400,000).

To determine what type of demand could be expected for engineering graduates the questionnaire asked: *"How many engineering graduates would you*

like to hire during 1953?" The total figures indicated a demand for 10,439 engineering graduates or 13.8% of those employed at the time of the survey (early 1953). (See No. 3, Appendix A.)

To determine the job categories in which 1953 graduates might eventually be employed, Question No. 4 asked: *"Of the engineering graduates you would like to hire in 1953, how many would you expect to be employed in each of the categories after five years of service?"* (See No. 4, Appendix A.) Those having Bachelor's degrees would account for:

82% of those in New Developments
94% of those in Operations
93% of those in Human Relations
and 88% of those in all three categories, after five years of employment.

Those having Master's degrees would account for:

13% in New Developments
5% in Operations
6% in Human Relations
and 9.5% in all three categories.

Those having Doctor's degrees would account for:

4.6% of those in New Developments
.6% of those in Operations
1.2% of those in Human Relations
and 2.8% of those in all three categories.

Industry estimated that those they would liked to have hired in 1953 would after five years service be distributed as follows:

53% in New Developments
28% in Operations
and 20% in Human Relations.

The discrepancy between the totals in Question No. 3 (10,439) and Question No. 4 (9,703) is due to the fact that some respondents did not answer Question No. 4.

To determine future demands the questionnaire addressed itself to the same general problem 10 years hence (1963). Question No. 5 asked: *"How many engineering graduates would you like to hire during 1963?"* All respondents did not answer this question; nevertheless the projected total was 10,314 or 15% of those (early 1953) employed in the companies answering this question.

Question No. 6 again asked for a classification of 1963 graduates according to the type of degree: *"Of the engineering graduates you would like to hire in 1963, how many would you expect to be employed in each of the categories after five years of service?"* (See No. 6, Appendix A.) Those having Bachelor's degrees after five years service would account for:

74% of those in New Developments
92.8% of those in Operations
89.8% of those in Human Relations
and 83.7% of those in all three categories.

Master's degrees based on these estimates after five years service (1968) would account for:

18.1% of those in New Developments
6.4% of those in Operations
7.6% of those in Human Relations
and 12.0% of those in all three categories.

Doctor's degrees would account for after five years service:

7.6% of those in New Developments
.7% of those in Operations
2.5% of those in Human Relations
and 4.3% of those in all three categories.

Again the totals in No. 5 and No. 6 do not agree, since not every respondent answered No. 6.

Engineering Curricula

The curriculum question was first mentioned in No. 7 which asked: *"Do you believe that the undergraduate college training should be different for the different categories listed after Question No. 1?"* (New Developments, Operations, and Human Relations). Of the 85 questionnaires received, 40 (47%) answered in the affirmative, 41 (48%) in the negative and 4 (5%) either did not respond or qualified their answer.

Those favoring different training for the different categories were then asked about subject matter as follows: *"If your answer to No. 7 is yes, what subjects should be emphasized to a greater extent for each category? (check one or more).* (See No. 7, Appendix A.) Those subjects checked 50% or more were:

In New Developments:

Advanced Science	65%
Engineering	50%
English—Speech	84%

In Operations:

Engineering	55%
English—Speech	73%
Economics—Psychology—Government	67%

In Human Relations:

English—Speech	97%
Economics—Psychology—Government	92%
Humanities	76%

It is important to note that *only* those who answered "yes" to Question No. 7, namely those in favor of different undergraduate training for engineers in New Developments, Operations, and Human Relations, answered this question.

The four-year vs. the five-year program was faced in Question No. 9 which asked: *"Do you favor a four year or a five year curriculum for the Bachelor's degrees in engineering?"* Opinion was again about equally divided, 43 (51%) favoring the four-year curriculum and 42 (49%) favoring the five-year program.

Those favoring the five-year program were then asked: *"If you favor the five-year curriculum, what subjects would you like to see emphasized to a greater extent?"* (See No. 10, Appendix A.) Those subjects checked more than 50% of the time were:

In New Developments:

English—Speech	90%

In Operations:

English—Speech	90%
Economics—Psychology—Government	74%
Humanities	51%

In Human Relations:

English—Speech	94%
Economics—Psychology—Government	81%
Humanities	75%

Only those favoring the five-year program answered this question.

The integrated program was considered in Question No. 11 which asked: *"Do you think there is need for an undergraduate curriculum offering an integrated, across the board type of program with emphasis on the subject matter and methods common to the major fields of engineering?"* There were 50 (59%) "yes's," 21 (25%) "no's," and 14 (16%) did not respond to this question. Those answering "yes" favored such a program for 42.2% of the undergraduates. (See Appendix A, Question No. 11.)

The relation of the technical institute program to engineering was approached in Question No. 12 which asked: *"If graduates of technical institutes (2 year training) were available in sufficient number, what percentage of the engineers you are now hiring would you be willing to replace by those with technical institute train-*

ing?" Some did not respond to this question and others commented that they would hire more technical institute graduate but not to replace engineers. The respondents' answers resulted in a 9.8% mean, more than one-half indicating that they would not hire any technical institute graduates in *place* of engineers.

Summary

As is often the case in designing a questionnaire, certain modifications seem desirable after the results are in. The results should be thought of as more or less qualitative in nature, since they lack the quantitative precision that engineers are accustomed to in physical measurements. The classification of employed engineers into the categories is based upon thousands of engineers, Questions No. 1–6. On the other hand the questions concerning the curriculum are based on the individual opinions of the 85 industry representatives who answered the questionnaire, Questions No. 7–12.

1. Industry indicates that about 4 out of 10 engineers are engaged in New Developments (research-design), 3 out of 10 in Operations (production-construction), and about 3 out of 10 in Human Relations (sales-supervision). About 9 out of 10 have Bachelor's degrees, about 1 out of 10 have Master's degrees and about 1 out of 100 have Doctor's degrees (varying from 4 out of 100 in New Developments to 2 in 1000 in Operations).

2. Based on the estimates for 1953 and 1963, industry would like to hire about 1 engineer for every 10 currently employed.

3. Industry indicated that during the next ten years a greater percentage of those with Master's and Doctor's degrees will be desired, but Bachelor's degrees will continue to constitute better than 80% of demand.

4. Those in charge of industry's college recruiting programs were about equally divided on specific trainfng of undergraduates for particular job categories, as contrasted with training in a common program for all job categories. Those favoring more specific programs prefer more advanced science and engineering for those in research and design, more social sciences for those in production and construction, and more social sciences and humanities for those in sales and supervision. Additional English and speech training seemed to be highly desirable for all job categories.

5. The replies indicated that industry was about equally divided between the four-year and the five-year programs. Those favoring the five-year program generally favored more humanities and social sciences for construction and production personnel and more social sciences and humanities for sales and supervision personnel. Again there was general unanimity on English and speech, over 90% of the respondents checking these subjects.

6. Fifty-nine per cent of the respondents thought there was a need for an integrated undergraduate program which would emphasize subject matter common to the major fields of engineering. Twenty-five per cent did not think there was a need for such a program and the remaining 16% did not respond to this question. Those who thought there was a need for an integrated program thought that about half of the students should take such a program.

7. It seems unlikely from the responses received that technical institute graduates will be hired instead of engineering graduates.

In closing it seems advisable to point out that these results in general represent the opinions of a limited number of key industry men who represent a small but important segment of industrial managements' opinions.

Acknowledgments

The important contributions of the industries cooperating in this survey are gratefully acknowledged. Without their help the survey would not have been possible.

The "Questionnaire on Evaluation of

(the) Engineering Curriculum" was prepared by a Curriculum Study Committee at Purdue consisting of:

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The original study committee deserves special credit for its foresight and insight in conceiving and designing the survey.

This report was prepared with the guidance of Purdue's Engineering Education Committee.

The Engineering Education Committee includes:

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C. O. Bennett
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K. B. Woods
J. L. Waling
L. E. Beck, *Chairman*

The suggestions of this committee are gratefully acknowledged.

APPENDIX A

Summary Tables of the Questionnaire on Evaluation of the Engineering Curriculum

1. Approximately how many persons with engineering degrees does your firm now employ?

Range: (3–13,375)
Median: 277
Frequency Distribution:

Number of Engineers	Number of Companies
7000–up	1
6000–6999	2
5000–5999	1
4000–4999	0
3000–3999	2
2000–2999	3
1000–1999	8
500– 999	17
300– 499	6
200– 299	11
100– 199	14
50– 99	11
0– 49	9
Total	85

2. How many of your employees having engineering degrees can be classified in each of the categories?

Degrees	Job Categories			Total Degrees
	A. New Developments	B. Operations	C. Human Relations	
	Number %	Number %	Number %	Number %
Bachelor's Degree	26,541 83.8%	22,056 95.9%	19.489 93.3%	68,086 90.1%
Master's Degree	4,119 13.0%	895 3.9%	1,346 6.4%	6,360 8.4%
Doctor's Degree	1,016 3.2%	42 .2%	61 .29%	1,119 1.5%
Total No. Degrees %	31,696 41.9%	22,993 30.4%	20,896 27.7%	75,565 Grand 100% Total

3. How many engineering graduates would you like to hire during 1953?

Numbers of Graduates	Per Cent of Grand Total—Question No. 2
10,439	13.8%

4. Of the engineering graduates you would like to hire in 1953, how many would you expect to be employed in each of the categories after five years of service?

Degrees	Job Categories			Total Degrees
	A. New Developments	B. Operations	C. Human Relations	
	Number %	Number %	Number %	Number %
Bachelor's Degree	4,200 82.2%	2,507 94.0%	1,797 93.1%	8,504 87.6%
Master's Degree	670 13.1%	145 5.4%	108 5.6%	923 9.5%
Doctor's Degree	237 4.6%	15 .6%	24 1.2%	276 2.8%
Total No. Degrees %	5,107 52.6%	2,667 27.5%	1.929 19.9%	9,703 Grand 100% Total

5. How many engineering graduates would you like to hire during 1963?

Number of Graduates	Per Cent of the Adjusted Grand Total
10,314	15.0%

6. Of the engineering graduates you would like to hire in 1963, how many would you expect to be employed in each of the categories after 5 years of service?

Degrees	Job Categories			Total Degrees
	A. New Developments	B. Operations	C. Human Relations	
	Number %	Number %	Number %	Number %
Bachelor's Degree	2,751 74.9%	2,275 92.8%	1,804 89.8%	6,830 83.7%
Master's Degree	663 18.1%	158 6.4%	153 7.6%	979 12.0%
Doctor's Degree	281 7.6%	18 .7%	51 2.5%	350 4.3%
Total No. Degrees %	3,700 45.3%	2,451 30.0%	2,008 24.6%	8,159 Grand 100% Total

7. Do you believe that the undergraduate college training should be different for the different categories listed after Question No. 1?

Response	Number of Responses	Per Cent of the Returned Questionnaires
Yes	40	47%
No	41	48%
No Response or Qualified	4	4.7%

8. If your answer to 7 is yes, what subjects should be emphasized to a greater extent for each category? (check one or more)

Subjects	Job Categories		
	A. New Developments	B. Operations	C. Human Relations
	Number of Checks	Number of Checks	Number of Checks
Basic Physics, Chem., Math.	15 48%	10 30%	8 22%
Advanced Physics, Chemistry, Math.	20 65%	2 6%	0 0%
Engineering Fundamentals (Mechanics, Thermo. Elec. & Magn.)	18 58%	18 55%	12 32%
Specialized Technology	15 48%	11 33%	3 8%
English—Speech	26 84%	24 73%	36 97%
Economics, Psych. Government	7 23%	22 67%	34 92%
Humanities (literature, philosophy, etc.)	5 16%	6 18%	28 76%
Total	31 100%	33 100%	37 100%

9. Do you favor a 4 year or a 5 year curriculum for the Bachelor's degree in engineering?

Response	Number of Responses	Per Cent of the Returned Questionnaires
4 year curriculum	43	50.6%
5 year curriculum	42	49.4%

10. If you favor the five year curriculum, what subjects would you like to see emphasized to a greater extent? (Check one or more)

Subjects	Job Categories		
	A. New Developments	B. Operations	C. Human Relations
	Number of Checks	Number of Checks	Number of Checks
Basic Physics, Chem., Math.	5 16%	4 13%	2 6%
Advanced Physics, Chemistry, Math.	11 36%	4 13%	2 6%
Engineering Fundamentals (Mechanics, Thermo. Elec. & Magn.)	15 48%	11 36%	7 22%
Specialized Technology	10 33%	8 26%	4 13%
English—Speech	28 90%	28 90%	29 94%
Economics, Psych. Government	15 48%	23 74%	25 81%
Humanities (literature, philosophy, etc.)	13 42%	17 51%	23 75%
Total	31 100%	31 100%	31 100%

11. Do you think there is need for an undergraduate curriculum offering an integrated, across-the-board type of program with emphasis on the subject matter and methods common to the major fields of engineering?

a)

Response	Number of Responses	Per Cent of the Returned Questionnaires
Yes	50	59%
No	21	25%
No Response	14	16%

b) If so, what percentage of students should take such a program? *Mean* 42.2%
Median 50.0%

12. If graduates of technical institutes (2 year training) were available in sufficient numbers, what percentage of the engineers you are now hiring would you be willing to replace by those with technical institute training?

Mean: Number of engineers 9.8%
Median: Number of engineers 0%

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472 new members elected this year

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ASSISTANT OR ASSOCIATE PROFESsor in Mechanics. Assistant or Associate Professor in Structures. A Master's degree together with experience in research, teaching or professional practice is essential. A Doctor's degree already obtained, or on the way, and/or professional experience are desirable. These positions are on the regular teaching staff.

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MECHANICAL ENGINEER—SOMEONE to teach heat subjects and normal mechanical engineering laboratories. Should be active in technical and professional organizations. Salary and academic rank depending upon degree and experience. Position starts September, 1955. Location, Ohio.

Continued on page 825

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Bucknell University	April 29–30, 1955	W. D. Garman, Bucknell University
Illinois-Indiana	University of Notre Dame	May 21, 1955	G. E. Ellithorn, University of Notre Dame
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	G. W. Bradshaw, University of Kansas
Michigan	Michigan State College	May 7, 1955	C. C. Sigerfoos, Michigan State College
Middle Atlantic	Swarthmore College	May 7, 1955	H. N. Jenkins, Swarthmore College
Missouri-Arkansas	University of Missouri	March 26, 1955	M. M. Jones, University of Missouri
*National Capital Area			J. C. Michalowicz, Catholic University
*New England			E. R. McKee, University of Vermont
*North Midwest			C. J. Pratt, Michigan College of M. and T.
Ohio	University of Akron	May 7, 1955	K. F. Sibila, University of Akron
Pacific Northwest	University of Idaho	April 15–16, 1955	M. L. Jackson, University of Idaho
*Pacific Southwest			B. M. Green, Stanford University
Rocky Mountain	Colorado A. & M. College	April 16, 1955	D. F. Peterson, Colorado A. and M. College
Southeast	University of Tennessee	April 14–16, 1955	H. V. Flinsch, Mississippi State College
Southwest	University of Oklahoma	April 8–9, 1955	V. L. Doughtie, University of Texas
*Upper New York			B. H. Norem, Syracuse University

Members of the Society are welcome at all Section Meetings

* No date set.

A SUMMER COURSE IN

Plastic Design in Structural Steel

Presented by *Lehigh University* and *The American Institute of Steel Construction* in cooperation with *The American Society for Engineering Education* and *The Engineering Mechanics and Structural Divisions* of The American Society of Civil Engineers

The Fritz Engineering Laboratory

LEHIGH UNIVERSITY

Bethlehem, Pennsylvania

September 7–15, 1955

During the past quarter-century, both in this country and abroad, research on the ultimate strength of steel structures has suggested challenging possibilities for the use of maximum (plastic) strength as a basis for structural design.

Traditionally, the measure of steel's total strength for construction purposes has been the largest load under which it is guaranteed to behave in a truly elastic manner. Present day building codes, based upon the elastic concept, are logical and economical for individual beams and pin-connected frames.

When members are rigidly connected, however, the structure as a whole has long been known to possess a much greater load-carrying capacity than indicated by the elastic concept. These continuous (or "rigid") frames are able to carry increased loads above "first yield" because structural steel has the capacity to yield plastically with no loss of strength; indeed, with frequent increase in resistance. This behavior results when the rigidly connected, continuous structure draws upon the reserve strength of its less heavily stressed portions.

Sensing the values to our economy of a full exploitation of this more realistic measure of steel's strength, Lehigh University began in 1937 a series of research projects on rigid steel frames and their components which still continues. Since 1946 the studies have been under the sponsorship of the American Institute of Steel Construction, the American Iron and Steel Institute, the Welding Research Council, and the Navy Department. The latter includes The Office of Naval Research, The Bureau of Ships, and The Bureau of Yards and Docks.

By the summer of this year, sufficient data will have been compiled to document the new design concept—calling upon the "ultimate" strength of structural steel as revealed by analysis of its plastic rather than elastic behavior under load.

The resulting techniques, already successfully applied in England, promise to produce substantial savings in cost through the more economic use of steel and savings in the design office made possible by the more simple plastic methods. At the same time, building frames will be more logically designed for greater overall strength.

In order that educators in particular may have an opportunity to introduce these new concepts into their teaching at

the earliest possible date, a special "summer" session has been arranged just prior to the opening of the fall college term.

The course will review the behavior of steel structures loaded beyond the elastic limit and will present the fundamental concepts of plastic analysis. Specific plastic design techniques will be presented and examples worked out. The course will consist of a series of lectures and demonstrations, the latter including actual tests of structures to illustrate the principles. These tests, which will be carried through the elastic and plastic ranges, will include columns, continuous beams, and full-sized connections of the type found in industrial buildings. Also, a complete frame will be tested, illustrating the accuracy with which the true strength of a steel frame—its "ultimate" strength—may be predicted.

Each of the lectures in the Summer Course will be an hour long with a fifteen minute intermission between the two morning lectures. For those attending who are interested in the further discussion of particular points, informal discussion sessions will be arranged during the evenings at Fritz Laboratory.

All lectures will be given by members of the staff of the Fritz Engineering Laboratory who have participated extensively in this research investigation for the past several years.

Continued from page 821

CHRYSLER INSTITUTE OF ENGINEERING

again has openings on its full time teaching staff. They are:

1. Supervisor of engineering graduates working on individual automotive design projects as a part of their Graduate School course. Duties would also include supervision of graduate classwork.

   Desired qualifications: Age 25–40; B.S. degree or higher in engineering; at least 2 years of college teaching experience; some design experience, preferably automotive.

2. Teacher and supervisor of Graduate School classwork. Qualifications: Age 25–40; M.S. degree in engineering; experience in teaching mechanical engineering subjects.

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Subject Index 1954-55

A.A.U.P. Symposium Papers—The Responsibility of the Physics Teacher in Engineering Education. N. H. Frank, L. P. Smith, L. E. Grinter, and H. L. Dodge .3, 242

Another Look at the Causes for Professional Bargaining Groups. A. A. K. Booth 4, 358

Approximation Methods in Nuclear Engineering. C. F. Bonilla 4, 328

Are Graduate Courses Millstones or Milestones? L. L. Otto 10, 763

Basic Science and Design in Soil Mechanics. H. P. Hall 4, 336

Biographical Sketch of Nathan W. Dougherty, President of ASEE 1, 1

Brief Report on the Salaries of Engineering Teachers Based upon Data Collected by Engineers' Joint Council in 1953, A. R. F. Henderson 3, 283

Building Blocks of Engineering Education. A. S. Levens 2, 155

Candid Comments. R. B. Davis 9, 736

Candid Comments. H. A. Marcoux .10, 807

Carnegie Conference. G. Murphy ..5, 418

Case Method in Engineering and Business Administration, The. H. B. Rogers 8, 627

Case Method of Teaching Mechanics. F. L. Singer 5, 444

Comments on Interim Report of Committee on Evaluation of Engineering Education 5, 411

Community Project in Professional Development. C. Wandmacher .5, 396

Complimentary Role of Physics and Mechanics in Engineering Education. Glenn Murphy 10, 753

Conference Method in Lab Courses. J. E. Gibson 7, 540

Construction of a Demonstration Slide Rule. W. K. Viertel 8, 660

Coordination. F. A. Hezcock 3, 295

Creative Engineering Program, The. C. F. Hix, Jr. 7, 514

Creative Process, The. E. K. Von Fange 7, 508

Creativity in Radio. J. R. Ragazzini 2, 112

Curriculum for Technical Editors, A. C. K. Arnold 3, 258

Discussion of "Engineering Education Across the Country." D. L. Trautman 8, 656

ECAC Conference on International Relations 9, 689

ECPD Accreditation of "Fringe" Curricula 5, 447

ECPD Accreditation Program. H. L. Hazen 2, 101

Educating Professionals. N. W. Dougherty 1, 5

Education for a Creative Professional Life. L. E. Grinter 1, 7

Education for Creative Leadership. L. R. Lohr 1, 24

Education for Creativity in Engineering. M. S. Gjesdahl 10, 766

Education of Leaders, The. R. B. Davis 10, 770

Education–Industry Cooperation for Increasing Planned Faculty Employment in Industry. G. K. Dreher 5, 454

Educational Requirements for Design and Development Engineers. W. E. Bradley 9, 704

Effect of Graduate Program on the Teacher. P. F. Chenea 9, 675

EJC and the Engineering Profession. T. A. Marshall, Jr. 2, 161

Employers, Ethics and Office Engineers. C. J. Freund 5, 408

Engineer as an Expert Witness, The. S. S. Aidlin 8, 649

Engineering Analysis as Training in Ingenuity. D. W. Ver Planck ..7, 523

Engineering Economy and Operations Research. L. G. Mitten ..7, 560

Engineering Education Across the Country. D. L. Trautman 3, 274

Engineering Education Behind the Iron Curtain. E. Keonjian 8, 593

ENGINEERING EDUCATION IN RUSSIA. M. H. Trytten 5, 389
ENGINEERING ETHICS—FROM THE VIEWPOINT OF INDUSTRY. G. E. Morse 3, 214
ENGINEERING GRADUATE IN AUTOMOTIVE INDUSTRY, THE. R. D. Amberson 8, 636
ENGINEERING GRADUATE PLACEMENT TEST RESEARCH. A. P. Johnson .2, 160
ENGINEERING SCHOOL OF TOMORROW, THE. M. O. Schmidt 10, 802
ENGINEERS' JOINT COUNCIL 5, 461
EVALUATING GOOD TEACHING. R. D. Stout 9, 669
EVALUATION OF ENGINEERING EDUCATION, COMMENTS ON INTERIM REPORT OF COMMITTEE ON 5, 411
EVALUATION OF ENGINEERING TEACHING ABILITY. T. H. Evans 9, 708

FACTORS AFFECTING THE SUPPLY OF GRADUATE STUDENTS IN ENGINEERING. D. F. Peterson 3, 231
"... FOR SUCH A TIME AS THIS." W. L. Everitt 7, 526
FUTURE ROLE OF GRADUATE STUDY IN ENGINEERING. E. Weber 3, 236

GEORGE WESTINGHOUSE AWARD—1954. Thomas J. Higgins 1, 83
GOALS OF RESEARCH. L. A. DuBridge 1, 34
GRADUATE CURRICULUM IN TECHNICAL WRITING. S. P. Olmsted 7, 557
GRADUATE STUDY IN BUILDING ENGINEERING AND CONSTRUCTION. W. H. Gumpertz 8, 619
GRADUATION, HOLD-BACK AND WITHDRAWAL RATES IN ENGINEERING COLLEGES. A. P. Johnson 3, 270
GRAPHICS AND DIFFERENTIAL EQUATIONS. S. A. Coons 7, 555
GROWTH OF GRADUATE STUDY IN ENGINEERING. H. H. Armsby 3, 220

HIGHLIGHTS OF THE 62ND ANNUAL MEETING OF ASEE. J. I. Mattill 1, 14
HOW IMPORTANT IS GRAPHICS TO THE PRACTICING ENGINEER?. O. W. Potter 5, 469
HOW SHOULD EXAMS BE GRADED? R. L. Sanks 7, 534
HOW SHOULD WE EDUCATE CIVIL ENGINEERS? B. A. Whisler 2, 142
HUMANISTIC–SOCIAL STUDIES IN THE ENGINEERING CURRICULA. E. S. Burdell 10, 747

IMPROVING STUDENT–TEACHER RELATIONSHIPS. F. D. Ezekiel 10, 758
IMPROVING THE TEACHING OF ENGINEERING. J. F. Downie Smith ...1, 73
INDIVIDUAL MANUFACTURING OPERATION, THE. J. F. Cleary 8, 642
INDUSTRY'S RESPONSIBILITY IN TRAINING ENGINEERS. F. J. Lockhart .8, 598
INDUSTRY VIEWS THE ENGINEERING GRADUATE AND HIS CURRICULUM. W. K. LeBold 10, 808
INITIATION OF RESEARCH, THE. W. C. Voss 2, 138
INTEGRATION OF HUMANITIES INTO AN ENGINEERING PROGRAM. J. S. Johnson 10, 805
INTERIM REPORT OF THE COMMITTEE ON EVALUATION OF ENGINEERING EDUCATION 1, 40
IS CALCULUS A PERFECT TOOL? K. Menger 3, 261

JAMES H. MCGRAW AWARD 7, 543

LAMME AWARD—1954—THORNDIKE SAVILLE 1, 80
LAYING THE FOUNDATION FOR ENGINEERING GRAPHICS 1, 85
LOOKING AHEAD. A. B. Bronwell 8, 577

MANUFACTURING PROCESS COURSES. M. L. Begeman and B. H. Amstead 7, 547
MATHEMATICS–ENGINEERING VERSUS ARTS. H. K. Fulmer 5, 436
MATHEMATICS FOR GRADUATE WORK IN ENGINEERING. J. W. Cell 5, 423
MCGRAW AWARD, JAMES H. 7, 543
MINUTES OF EXECUTIVE BOARD MEETING 2, 189
MINUTES OF EXECUTIVE BOARD MEETING 3, 298
MINUTES OF EXECUTIVE BOARD MEETING 5, 462
MINUTES OF EXECUTIVE BOARD MEETING 7, 564
MINUTES OF EXECUTIVE BOARD MEETING 9, 721
MINUTES OF GENERAL COUNCIL MEETING 2, 193
MINUTES OF GENERAL COUNCIL MEETING 5, 465
MUNIFICENT GIFTS THAT LEAD TO GOOD TEACHERS. E. C. Thoma 2, 131

NEW POSITION OF SCIENCE, THE. G. E. Doan 8, 589

NEWS OF ENGINEERS' JOINT COUNCIL 2, 198
NUCLEAR EDUCATION FOR ENGINEERS. A. M. Anderson 9, 678

OBJECTIVE TESTING IN MECHANICS. C. J. Pratt 9, 683
OFFICERS OF DIVISIONS, COMMITTEES AND SECTIONS 2, 200
ON TEACHING CREATIVE ENGINEERING. C. D. Fulton 10, 794
OPPORTUNITY UNLIMITED. H. E. Fritz 4, 322
OUR SCHOOLS CAN TEACH WRITING—IF THEY ARE MADE TO. J. H. Wilson, Jr. 5, 431

PENNSYLVANIA STATE UNIVERSITY ..5, 385
PENNSYLVANIA STATE UNIVERSITY, COLLEGE OF INDUSTRY AND AGRICULTURE 7, 501
PERSONALITY FACTORS IN THE LEARNING PROCESS. W. R. LePage 8, 603
PHILOSOPHY OF THE COOPERATIVE PROGRAM. C. E. Watson 2, 134
PHYSICS IN ENGINEERING EDUCATION 9, 727
PLACE OF THE SOCIO-HUMANITIES STUDIES IN PROFESSIONAL GRADUATE INSTRUCTION. W. L. Everitt .1, 69
POLYTECHNICAL INSTRUCTION IN SOVIET SECONDARY SCHOOLS. S. Kownacki 10, 787
PROFESSIONAL DEVELOPMENT OF ENGINEERING TEACHERS. N. W. Dougherty 4, 307
PROFESSIONAL GENERAL CURRICULUM IN POWER. A. J. A. M. Lyon 9, 700
PROFESSIONAL UNION—A CONTRADICTION 4, 345
PROGRESS IN TEACHING ENGLISH TO ENGINEERS. C. A. Brown 5, 428
PUBLICATION AS A MOTIVATION FOR ADVANCED STUDENTS. J. S. McNown 9, 672
PURDUE CONFERENCE ON THERMODYNAMICS 9, 728

RECOGNIZING AND REWARDING GOOD TEACHING. R. W. Schmelzer 2, 216
RELATIONS WITH REGIONAL ACCREDITING ASSOCIATIONS. H. L. Hazen .3, 209
REMUNERATION POLICIES OF ENGINEERING COLLEGES IN REGARD TO RESEARCH AND CONSULTING. V. E. Neilly 5, 449
REPORT OF ASEE—GENERAL ELECTRIC COMPANY SEMINAR. R. H. Buescher 7, 519
REPORT OF COMMITTEE ON PROMOTION OF ETHICAL STANDARDS 1, 67
REPORT OF CONFERENCE ON ELECTRICITY AND MAGNETISM 9, 721
REPORT OF THE ASEE MANPOWER COMMITTEE. D. S. Bridgman 2, 147
REPORT ON THE RESOLUTIONS COMMITTEE 2, 197
REPORT OF THE SECRETARY 1953/54 ..1, 87
REPORT OF THE TREASURER 2, 182
REPORT ON ASEE SUMMER INSTITUTES ON INCLUSION OF MODERN AND SOLID STATE PHYSICS IN THE CURRICULA OF ALL ENGINEERS. C. Beck 3, 254
REPORT ON ENGINEERING MATHEMATICS 8, 583
REPORT ON STUDY OF ROTC CURRICULA. E. C. Easton 8, 612
REPORT ON THE CARNEGIE CONFERENCE. G. Murphy 5, 418
REPORTS OF VICE PRESIDENTS 2, 173
REQUIREMENTS FOR ENGINEERING IN THE COMMUNICATIONS OPERATING FIELD. H. I. Romnes 4, 370
ROLE OF ENGINEERING MECHANICS IN ENGINEERING EDUCATION. P. F. Chenea 5, 438
ROLE OF PHYSICS IN ENGINEERING EDUCATION. N. H. Frank 5, 404

SHIFT OF EMPHASIS IN THE ENGINEERING CURRICULUM. E. J. Lindahl 10, 780
SHORTAGE OF TECHNICAL PERSONNEL. W. J. Moreland 3, 265
SONS OF MARTHA; IN UNIVERSITY HALLS, IN PROFESSIONAL PRACTICE, IN COMMUNITY UPBUILDING, THEY SERVE. W. R. Woolrich ..4, 314
STRESS THE FUNDAMENTALS—APPLIED. D. I. Cook 7, 538
SUGGESTED RESEARCH POLICY FOR THE GUIDANCE OF ENGINEERING SCHOOLS. E. A. Walker 2, 171
SUMMER EMPLOYMENT FOR COLLEGE PROFESSORS 4, 374

TEACHING DESIGN BY MOTIVATION. L. Harrisberger 4, 367
TEACHING ENGINEERING ETHICS. M. D. Cooper 7, 545
TEACHING ENGINEERING GRAPHICS EFFECTIVELY. F. A. Heacock 9, 730
TEACHING TIPS. W. K. Viertel 3, 296
TECHNICAL INSTITUTE AND SOME OF ITS PROBLEMS. C. S. Jones 2, 150
TECHNIQUES USED BY THE ARMED SERVICES. C. R. Nichols 4, 361

THERMODYNAMICS CONFERENCE—PENN STATE 9, 726
THERMODYNAMICS FOR CHEMICAL ENGINEERS. F. M. Tiller 8, 658
THERMODYNAMICS FOR ENGINEERS. A. B. Cambel 3, 240
THWARTING THE TWO-DAY TERM REPORT. J. D. Thomas 2, 158
TIMELY TIPS. W. A. Gross 3, 297
TRAINING ENGINEERS FOR RESEARCH. C. E. Balleisen 4, 333

ULTIMATE STRENGTH THEORY IN A SENIOR COURSE. P. M. Ferguson 4, 340
UNDERGRADUATE THESIS IN ENGINEERING EDUCATION. R. L. Sanks 8, 645
UNIONIZATION OF ENGINEERS—A REEXAMINATION. G. W. Miller ...10, 775
UPADI—WHAT IT IS, WHAT IT DOES 7, 542

VIBRATION PROBLEMS. J. J. Ryan ...7, 531
VISUAL AIDS IN ENGINEERING EDUCATION. R. W. Pinger 8, 652

WHAT IS AND WHAT WILL CONTINUE TO BE THE SUPPLY OF PEOPLE QUALIFIED TO DO GRADUATE WORK IN ENGINEERING? C. O. Harris .3, 227

YET-ITUDES 8, 634
YET-ITUDES 9, 687
YET-ITUDES 10, 761
YETS? WHAT'S THAT? R. I. Howe ..3, 280

Author Index 1954-55

ADAMS, M. D. Summer Employment for College Professors 4, 374
AIDLIN, S. S. The Engineer as an Expert Witness 8, 649
AMBERSON, R. D. The Engineering Graduate in Automotive Industry ...8, 636
AMSTEAD, B. H., AND BEGEMAN, M. L. Manufacturing Process Courses .7, 547
ANDERSON, A. M. Nuclear Education for Engineers 9, 678
ARMSBY, H. H. The Growth of Graduate Study in Engineering 3, 220
ARNOLD, C. K. A Curriculum for Technical Editors 3, 258

BALLEISEN, C. E. Training Engineers for Research 4, 333
BECK, C. Report on ASEE Summer Institutes on Inclusion of Modern and Solid State Physics in the Curricula of All Engineers 3, 254
BEGEMAN, M. L. AND AMSTEAD, B. H. Manufacturing Process Courses .7, 547
BONILLA, C. F. Approximation Methods in Nuclear Engineering 4, 328
BOOTH, A. A. K. Another Look at the Causes for Professional Bargaining Groups 4, 358
BRADLEY, W. E. Educational Requirements for Design and Development Engineers 9, 704
BRIDGMAN, D. S. Report of the ASEE Manpower Committee 2, 147
BRONWELL, A. B. Looking Ahead ...8, 577
BROWN, C. A. Progress in Teaching English to Engineers 5, 428
BUESCHER, R. H. Report of ASEE-General Electric Company Seminar 7, 519
BURDELL, E. S. Humanistic-Social Studies in the Engineering Curricula 10, 747

CAMBEL, A. B. Thermodynamics for Engineers 3, 240
CELL, J. W. Mathematics for Graduate Work in Engineering 5, 423
CHENEA, P. F. Role of Engineering Mechanics in Engineering Education 5, 438
CHENEA, P. F. Effect of Graduate Program on the Teacher 9, 675
CLEARY, J. F. The Individual Manufacturing Operation 8, 642
COOK, D. I. Stress the Fundamentals—Applied 7, 538
COONS, S. A. Graphics and Differential Equations 7, 555
COOPER, M. D. Teaching of Engineering Ethics 7, 545

DAVIS, R. B. Candid Comments 9, 736
DAVIS, R. B. The Education of Leaders 10, 770
DOAN, G. E. The New Position of Science 8, 589
DODGE, H. L. A.A.U.P. Symposium Papers—The Responsibility of the Physics Teacher in Engineering Education 3, 250
DOUGHERTY, N. W. Educating Professionals 1, 5
DOUGHERTY, N. W. Professional Development of Engineering Teachers 4, 307
DREHER, G. K. Education-Industry Cooperation for Increasing Planned Faculty Employment in Industry 5, 454
DUBRIDGE, L. A. Goals of Research ..1, 34

EASTON, E. C. Report on Study of ROTC Curricula 8, 612
EVANS, T. H. Evaluation of Engineering Teaching Ability 9, 708
EVERITT, W. L. ". . . For Such a Time as This" 7, 526
EVERITT, W. L. The Place of the Socio-Humanistic Studies in Professional Graduate Instruction 1, 69
EZEKIEL, F. D. Improving Student-Teacher Relationships 10, 758

FARBER, E. A. The Teaching and Learning of Engineering 10, 784
FERGUSON, P. M. Ultimate Strength Theory in a Senior Course 4, 340
FRANK, N. H. A.A.U.P. Symposium Papers—The Responsibility of the Physics Teacher in Engineering Education 3, 242

FRANK, N. H. The Role of Physics in Engineering Education 5, 404
FREUND, C. J. Employers, Ethics and Novice Engineers 5, 408
FRITZ, H. E. Opportunity Unlimited .4, 322
FULMER, H. K. Mathematics–Engineering versus Arts 5, 436
FULTON, C. D. On Teaching Creative Engineering 10, 794

GIBSON, J. E. Conference Method in Lab Courses 7, 540
GJESDAHL, M. S. Education for Creativity in Engineering 10, 766
GRINTER, L. E. A.A.U.P. Symposium Papers—The Responsibility of the Physics Teacher in Engineering Education 3, 246
GRINTER, L. E. Education for a Creative Professional Life 1, 7
GROSS, W. A. Timely Tips 3, 297
GUMPERTZ, W. H. Graduate Study in Building Engineering and Construction 8, 619

HALL, H. P. Basic Science and Design in Soil Mechanics 4, 336
HARRIS, C. O. What Is and What Will Continue to Be the Supply of People Qualified to Do Graduate Work in Engineering? 3, 227
HARRISBERGER, L. Teaching Design by Motivation 4, 367
HAZEN, H. L. Relations with Regional Accrediting Associations 3, 209
HAZEN, H. L. The ECPD Accreditation Program 2, 101
HEACOCK, F. A. Coordination 3, 295
HEACOCK, F. A. Teaching Engineering Graphics Effectively 9, 730
HENDERSON, R. F. A Brief Report on the Salaries of Engineering Teachers Based upon Data Collected by Engineers' Joint Council in 1953 .....3, 283
HIX, JR., C. F. The Creative Engineering Program 7, 514
HOWE, R. T. YETs? What's That? ..3, 280

JOHNSON, A. P. Engineering Graduate Placement Test Research 2, 160
JOHNSON, A. P. Graduation, Hold-Back and Withdrawal Rates in Engineering Colleges 3, 270
JOHNSON, J. S. Integration of Humanities into an Engineering Program 10, 805
JONES, C. S. The Technical Institute and Some of Its Problems 2, 150

KEONJIAN, E. Engineering Education Behind the Iron Curtain 8, 593
KOWNACKI, S. Polytechnic Instruction in Soviet Secondary Schools ...10, 787

LE BOLD, W. K. Industry Views the Engineering Graduate and His Curriculum 10, 808
LE PAGE, W. R. Personality Factors in the Learning Process 8, 603
LEVENS, A. S. Building Blocks of Engineering Education 2, 155
LINDAHL, E. J. Shift of Emphasis in the Engineering Curriculum ...10, 780
LOCKHART, F. J. Industry's Responsibility in Training Engineers ...8, 598
LOHR, L. R. Education for Creative Leadership 1, 24
LYON, J. A. M. A Professional General Curriculum in Power 9, 700

MARCOUX, H. A. Candid Comments .10, 807
MARSHALL, JR., T. A. EJC and the Engineering Profession 2, 161
MATTILL, J. I. Highlights of the 62nd Annual Meeting of ASEE 1, 14
MCGUIRE, J. G. Laying the Foundation for Engineering Graphics 1, 85
MCNOWN, J. S. Publication as a Motivation for Advanced Students ..9, 672
MENGER, K. Is Calculus a Perfect Tool? 3, 261
MILLER, G. W. Unionization of Engineers—a Reexamination 10, 775
MITTEN, L. G. Engineering Economy and Operations Research 7, 560
MORELAND, W. J. The Shortage of Technical Personnel 3, 265
MORSE, G. E. Engineering Ethics—from the Viewpoint of Industry 3, 214
MURPHY, G. Report on the Carnegie Conference 5, 418
MURPHY, G. Complimentary Role of Physics and Mechanics in Engineering Education 10, 753

NEILLY, V. E. Remuneration Policies of Engineering Colleges in Regard to Research and Engineering 5, 449
NICHOLS, C. R. Techniques Used by the Armed Services 4, 361

OLMSTEAD, S. P. Graduate Curriculum in Technical Writing 7, 557

OTTO, L. L. Are Graduate Courses Millstones or Milestones? 10, 763

PETERSON, D. F. Factors Affecting the Supply of Graduate Students in Engineering 3, 231
PINGER, R. W. Visual Aids in Engineering Education 8, 652
POTTER, O. W. How Important is Graphics to the Practicing Engineer? .5, 469
PRATT, C. J. Objective Testing in Mechanics 9, 683

RAGAZZINI, I. R. Creativity in Radio .2, 112
ROGERS, H. B. The Case Method in Engineering and Business Administration 8, 627
ROMNES, H. I. Requirements for Engineering in the Communications Field 4, 370
RYAN, J. J. Vibration Problems 7, 531

SANKS, R. L. How Should Exams be Graded? 7, 534
SANKS, R. L. Undergraduate Thesis in Engineering Education 8, 645
SCHMELZER, R. W. Recognizing and Rewarding Good Teaching 2, 126
SCHMIDT, M. O. The Engineering School of Tomorrow 10, 802
SHOCK, C. T. The Professional Union—a Contradiction 4, 345
SINGER, F. L. A Case Method of Teaching Mechanics 5, 444
SMIRNOFF, M. V. What is Wrong with Surveying? 9, 713
SMITH, J. F. D. Improving the Teaching of Engineering 1, 73
SMITH, L. P. A.A.U.P. Symposium Papers—The Responsibility of the Physics Teacher in Engineering Education 3, 243
STOUT, R. D.—Evaluating Good Teaching 9, 669
SWEIGERT, R. L. The Triumvirate for Improving and Maintaining Good Teaching 2, 120

THOMA, E. C. The Munificent Gifts That Lead to Good Teachers ...2, 131
THOMAS, J. D. Thwarting the Two-Day Term Report 2, 158
TILLER, F. M. Thermodynamics for Chemical Engineers 8, 658
TRAUTMAN, D. L. Engineering Education Across the Country 3, 274
TRAUTMAN, D. L. Discussion of "Engineering Education Across the Country" 8, 656
TRYTTEN, M. H. Engineering Education in Russia 5, 389

VER PLANCK, D. W. Engineering Analysis as Training in Ingenuity .7, 523
VIERTEL, W. K. Teaching Tips 3, 296
VIERTEL, W. K. Teaching Tips 8, 660
VON FANGE, E. K. The Creative Process 7, 508
VOSS, W. C. The Initiation of Research 2, 138

WALKER, E. A. A Suggested Research Policy for the Guidance of Engineering Schools 2, 171
WANDMACHER, C. A. Community Project in Professional Development .5, 396
WATSON, C. E. Philosophy of the Cooperative Program 2, 134
WEBER, E. The Future Role of Graduate Study in Engineering 3, 236
WHISLER, B. A. How Should We Educate Civil Engineers? 2, 142
WILSON, JR., J. H. Our Schools Can Teach Writing—If They Are Made to 5, 431
Woolrich, W. R. Sons of Martha; in University Halls, in Professional Practice, in Community Upbuilding, They Serve 4, 314